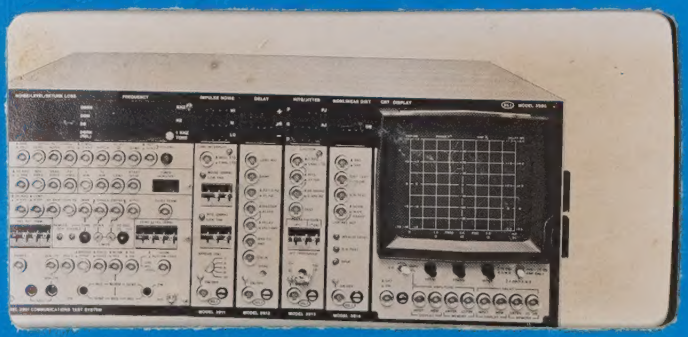
MODEL 3900
COMMUNICATIONS TEST SYSTEM

OPERATING MANUAL



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Self Test
3.5
Rq.

OPERATING MANUAL
MODEL 3901
COMMUNICATIONS TEST SYSTEM
BASIC UNIT

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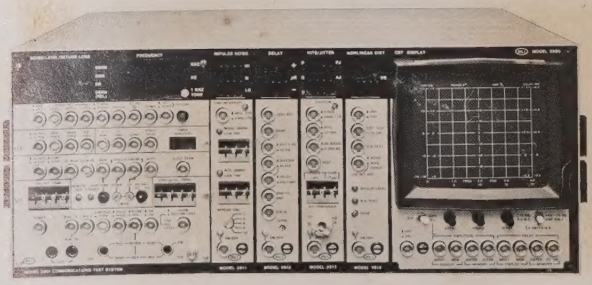

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OPERATING MANUAL
MODEL 3901 COMMUNICATIONS TEST SYSTEM BASIC UNIT

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1. GENERAL

1.01 This manual contains information needed for installation and operation of the HLI Model 3901 COMMUNICATIONS TEST SYSTEM Basic Unit. This section covers the functional description and specifications of the Basic Unit. Figure 1 shows the Model 3901 COMMUNICATIONS TEST SYSTEM with selected plug-in modules installed.

DANGER: Hazardous voltages exist inside this instrument.

A. Functional Description

1.02 The Model 3901 Basic Unit provides the following line interface arrangements.

- 4-wire/2-wire
- Handset/headset compatible
- Dual hold

1.03 The Basic Unit measure the following transmission parameters of communications channels, up to 20 kHz:

- Level
- Noise (voiceband filter weighted)
- Noise-to-ground (voiceband filter weighted)
- Sine wave return loss
- Frequency

1.04 The Basic Unit has a signal generator which can be set to function in the following modes:

- 1004 Hz holding tone
- Manually tuned oscillator
- Automatic sweep oscillator

The generator output level can be varied by using front panel thumbwheel switches.

1.05 The Basic Unit has a built-in, self-test capability for performing the following checks:

- Level/noise
- Frequency counter
- Signal generator
- Filter response

B. Specifications

1.06 Specifications for the Model 3901 Basic Unit are contained in Table A.

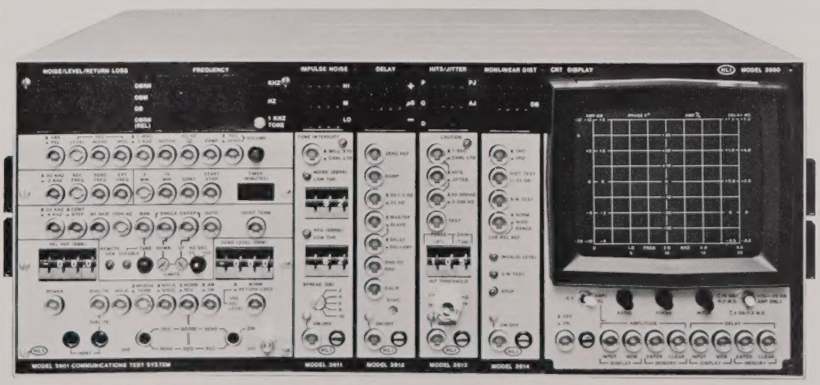

Figure 1. Model 3901 COMMUNICATIONS TEST SYSTEM (with Selected Plug-In Modules Installed)

TABLE A. MODEL 3901 SPECIFICATIONS*

LEVEL MEASUREMENT	
Frequency Range	40 Hz to 20 kHz
Level Range	+10.0 to −80.0 dBm
Relative Adjustment Range	+9.9 to −39.9 dBm
Accuracy	±0.1 dB at 1000 Hz from 0 to −19 dBm ±0.2 dB from +10.0 to −50 dBm, 200 Hz to 15 kHz ±0.5 dB from +10.0 to −50 dBm, 40 Hz to 20 kHz
NOISE MEASUREMENT	
Weighting Filters	C Message; 3 kHz Flat; Holding Tone Notch
Measurement Range	+10 to +100 dBrn (noise) +40 to +130 dBrn (noise-to-ground) ±1.0 dB (noise) ±1.5 dB (noise-to-ground)
FREQUENCY MEASUREMENT	
Measurement Range	40 to 19,999 Hz (20 kHz range) 40.0 to 1,999.9 Hz (2 kHz range)
Resolution	1 Hz (20 kHz range) 0.1 Hz (2 kHz range)
Accuracy	±1 Hz (20 kHz range) ±0.1 Hz (2 kHz range)
Update	10/second (20 kHz range) 1/second (2 kHz range)
SINE WAVE RETURN LOSS	
Measurement Range	0.0 to +50.0 dB (2-wire) −9.9 to +50.0 dB (4-wire)
Accuracy	±0.5 dB (4-wire)
Standard Impedance (2-wire)	600 Ω, 900 Ω ±1% in series with 2.16 μF ±1%, or external standard
SIGNAL GENERATOR	
Frequency Range	40 Hz to 4 kHz, 200 Hz to 20 kHz, switch selectable
Modes	Manual, Automatic Sweep, Single Sweep Up, Single Sweep Down, 1004 Hz
Control	Continuous and 100 Hz lock with +4 Hz offset
Sweep Limits	Front panel adjustable
SF Skip	Frequency skip and/or Mute (factory set at customer's option)
Level Range	+9.9 to −39.9 dBm, quiet termination
Level Resolution	0.1 dB
Level Accuracy	±0.1 dB to 15 kHz, ±0.2 dB to 20 kHz
Distortion	> 50 dB below signal (100 Hz to 20 kHz) > 60 dB below signal (1004 Hz)
TIMER	
Interval	5 min., 15 min., continuous
Display	Elapsed time in 0.1 minute increments
Capacity	999.9 minutes (16 hours, 40 minutes)

TABLE A. MODEL 3901 SPECIFICATIONS (Cont.)

GENERAL	
Terminated Impedance	600 Ω, 900 Ω, with 200 V dc block
Bridging Impedance	Causes less than 0.2 dB bridging loss error
Balance	> 80 dB at 60 Hz
Return Loss	> 30 dB
Hold/Dial/Talk	Full 2-wire/4-wire capability (Two 2-wire holding circuits are provided)
Monitor Speaker	Rear panel. Front panel volume control (approx. 250 mW)
EXTERNAL OUTPUTS	
DC	Proportional to Frequency Proportional to dB Level Proportional to Group Delay
AC	Monitor Output Phase Jitter Waveform Amplitude Jitter Waveform Receive and Send Binding Post Connections
POWER	105-130/210-260 Vac (switch selectable) 47-63 Hz, 20 to 80 watts depending on modules selected
SIZE	
3900L (8 Plug-ins)	17.25 in. (43.8 cm.) W x 7 in. (17.8 cm.) H x 17.85 in. (45.3 cm.) D
3900S (4 Plug-ins)	11.85 in.(30.1 cm.) W x 7 in. (17.8 cm.) H x 19.35 in. (49.2 cm.) D
WEIGHT	25-40 lbs. (11.3-18.1 kg.) depending on installed modules.

* All stated and unstated specifications are intended to comply with Bell System standards as contained in Bell System Technical Reference PUB 41009 dated May 1975

HLI reserves the right to make changes in specifications at any time without notice.

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2. AC POWER CONSIDERATIONS

2.01 This section contains information pertaining to the ac power connection and power sources compatible with the Model 3901 Basic Unit.

2.02 The Basic Unit may be operated from a source of 105 V ac to 130 V ac, or 210 V ac to 260 V ac at line frequencies from 47 Hz to 63 Hz.

WARNING: Failure to set the 115/230 volt selector switch to the proper setting before connecting the power cord to the power source may damage the unit.

With the power cord disconnected, move the 115/230 volt selector switch (located on the rear panel as shown in Figure 2) until the desired voltage indication of **115** or **230** is visible. A narrow-blade screwdriver may be used to operate the switch. The fuse should be a 1 ampere slow-blow for 115 volt operation or a 0.5 ampere slow-blow for 230 volt operation.

2.03 The Basic Unit is supplied with a detachable three-conductor power cable (Belden PN KH-8828) which, when plugged into an appropriate receptacle, grounds the chassis to the power line ground. To retain this protective feature when the power cable is plugged into a two-wire outlet, use a three-conductor to two-conductor adapter and connect the adapter wire to an appropriate ground.

2.04 If for any reason the chassis cannot be grounded through the power cable, it is recommended that the Basic Unit be grounded via the front panel (refer to Figure 3) ground post, by the GND terminals on the rear panel barrier strip, or any of the three black, five-way binding posts located on the rear panel.

2.05 When the unit is received, it is recommended that the self-test procedure in Section 15 be performed to determine that the unit is electrically operational.

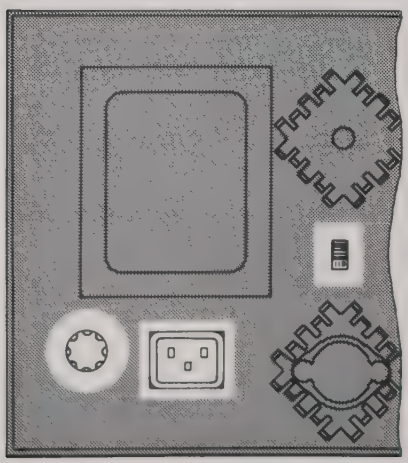

Figure 2. Rear Panel AC Power Receptacle, 115/230 Volt Selector Switch, and Fuse

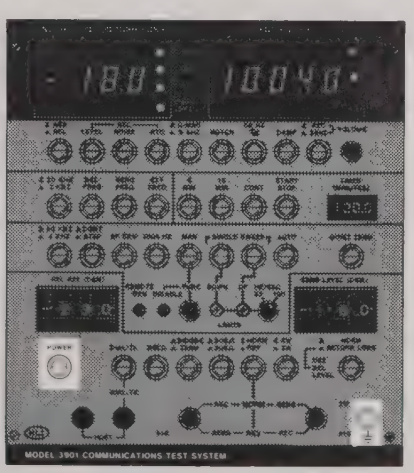

Figure 3. Front Panel AC Power Switch and Ground Post

3. CONTROLS, INDICATORS AND JACKS

3.01 This section contains descriptions of all controls, indicators and jacks on the Model 3901 Basic Unit. See Figure 4.

(1) DIAL/TK, HDST Jacks

Provides connection for a lineman's handset or a headset.

(2) POWER Switch

Switches Basic Unit power on and off.

(3) Thumbwheel Switches

REL REF (DBM) – Sets reference level from +9.9 to –39.9 dBm for relative measurement.

SEND LEVEL (DBM) - Sets send level from +9.9 to –39.9 dBm.

(4) Generator Mode Controls and Indicator

20 KHZ/4 KHZ – Sets generator range to either 20 kHz or 4 kHz.

CONT/STEP – Selects continuous frequency adjustment or discrete adjustment in 100 Hz steps.

SF SKIP – Sets the generator to skip from 2450 to 2750 Hz. It can be made to mute and/or skip at customer's option.

REMOTE GEN – Indicates when basic unit generator is not supplying the send signal.

(5) Frequency Counter Controls

20 KHZ/2 KHZ – Sets counter range. In 20 kHz range, counter updates 10/sec with 1 Hz resolution. In 2 kHz range, counter updates 1/sec with 0.1 Hz resolution.

REC FREQ – Selects receive frequency for display.

SEND FREQ – Selects send frequency for display. Send frequency can be displayed even in QUIET TERM mode.

EXT FREQ – Selects external frequency (applied via 5-way binding posts on the rear panel) for display.

(6) LEVEL/NOISE/NTG Controls

ABS/REL – Allows level readout to be either absolute or relative to the setting of REL REF (DBM) thumbwheels.

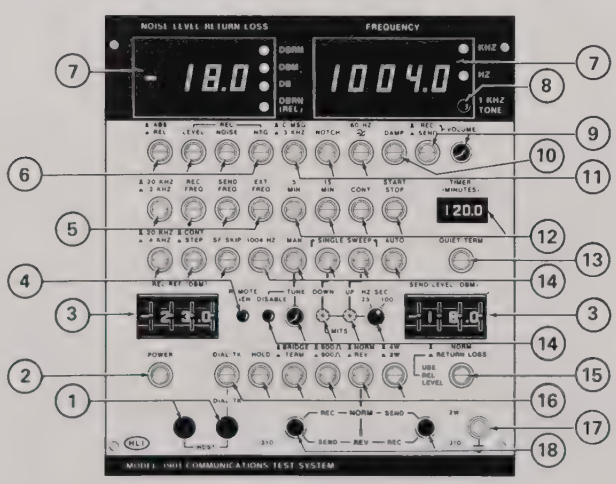

Figure 4. Controls, Indicators and Jacks

REC-LEVEL – Allows signal to bypass all noise weighting filters with the exception of 60 Hz ≈ filter.

REC-NOISE – Allows measurement of metallic noise (circuit noise) which has been weighted through noise weighting filters.

REC-NTG – Allows measurement of longitudinal noise (noise-to-ground) which has been weighted through noise weighting filters.

(7) LED Displays

LED readouts provide simultaneous information for level and frequency. Overrange is indicated with + sign while – sign indicates underrange. Appropriate units of measurement are given by LED indicators.

(8) 1 KHZ TONE Indicator

On when valid holding tone is received. Flashes when level is valid but frequency is from 980 to 990 Hz or from 1030 to 1040 Hz.

(9) Audio Controls

REC/SEND – Selects either receive or send signal for audio monitoring. Also feeds MON pin on the rear panel barrier strip.

VOLUME – Adjusts level of audio.

(10) DAMP Switch

Damps fluctuating reading.

(11) Filter Controls

C-MSG/3 KHZ – Provides selected weighting filter for noise measurement.

NOTCH – Notches out holding tone by more than 50 dB from 995 to 1025 Hz.

60 HZ ≈ – Reduces effect of power line interference on the reading. Can be used in all measurement modes.

(12) Timer Controls and Display

5 MIN – Sets timer interval to 5 minutes.

15 MIN – Sets timer interval to 15 minutes.

CONT – Timer runs until stopped by START/STOP switch.

START/STOP – Starts and stops timer.

TIMER (MINUTES) – Displays elapsed time with 0.1 minute resolution.

(13) QUIET TERM Switch

Provides a quiet termination on send line.

(14) Generator Frequency Controls and Indicator

1004 HZ – Selects 1004 Hz test tone with better than 60 dB purity.

MAN – Allows frequency to be manually tuned.

TUNE – Knob for manual tuning of frequency.

TUNE-DISABLE – Indicates when the basic unit tuning controls are disabled.

SINGLE SWEEP DOWN – Single sweeps the generator to the down limit.

SINGLE SWEEP UP – Single sweeps the generator to the up limit.

UP, DOWN LIMITS – Sets up and down sweep limits.

AUTO – Automatically sweeps generator between up and down limits.

HZ/SEC – Adjusts sweep rate.

(15) NORM/RETURN LOSS Switch

Selects normal or return loss measurement.

(16) Line Interface Controls

DIAL/TK – Used to dial and talk. When DIAL/TK is in, send function is disabled.

HOLD – Dual electronic hold circuit; holds 2-wire lines.

BRIDGE/TERM – Provides termination of both receive and send lines or bridges across receive lines.

600 Ω/900 Ω – Select to match line impedance.

NORM/REV – When set to NORM, the 310 jack on the right is the send jack and the 310 jack on the left is the receive jack. When set to REV, the jack functions are reversed.

4W/2W – Sets up Dial/Talk and Return Loss circuitry for 4-wire or 2-wire operation.

(17) Ground Post

The Basic Unit chassis is normally grounded through the power line. Where three-conductor power line is not available, the chassis should be grounded via this post.

(18) REC, SEND Jacks

The type 310 jacks provide interface between the test set and lines.

4. LINE INTERFACES

4.01 This section describes the line interface connections required to perform the various measurements described in subsequent sections.

4.02 The Model 3901 Basic Unit has two sets of balanced terminals and is capable of sending and receiving signals simultaneously. It is recommended that Western Electric 310 plugs or equivalent be used for line interface connections. Other types of audio plugs will deform the contacts and cause unsatisfactory performance of the 310 jacks. Refer to Figure 5 while performing the following line interface procedures.

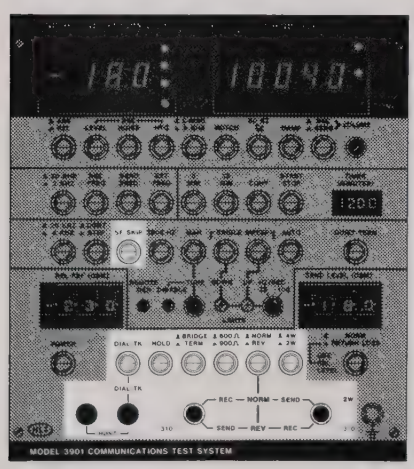

Figure 5. Line Interface Controls and Connectors

A. Impedance

4.03 The Basic Unit provides the two commonly used terminating impedances of 600 Ω and 900 Ω. The desired impedance is selected by setting the 600 Ω/900 Ω switch to the desired position.

Note: Failure to select the proper impedance will cause errors in both send and receive levels.

4.04 The Basic Unit can be bridged across or used as the terminating impedance for the receive line, by setting the BRIDGE/TERM switch to the appropriate position.

Note: In bridge mode, the send and receive levels are referenced to the selected terminating impedance (600 Ω or 900 Ω) although the bridging impedance is in excess of 25 kΩ.

B. Normal/Reverse

4.05 The NORM/REV switch enables the function of the two SEND/REC jacks to be interchanged and may be used in 2-wire or 4-wire operation. When the NORM/REV switch is set to NORM, the 310 jack on the right functions as the SEND jack and the 310 jack on the left functions as the REC jack. Setting the switch to REV reverses the functions.

4.06 There are two sets of five-way binding posts located on the rear panel (Figure 15, Section 14) for use when the Basic Unit is rack mounted. The T, R, and S binding posts are connected in parallel with the Basic Unit front panel NORM-REC jack, and the 2W-T1, -R1 and -S1 binding posts are connected in parallel with the front panel NORM-SEND jack.

4.07 The EXT-T, -R, -S five-way binding posts on the rear panel may be connected to the line for the purpose of frequency measurement only. These binding posts bridge across the line with a bridging impedance in excess of 10 kΩ for frequencies higher than 1 kHz.

C. 2-Wire

4.08 To interface with 2-wire lines, proceed as follows:

1) Set DIAL/TK switch to out position.
2) If it is necessary to hold the line under test, set HOLD switch to in position.
3) Set BRIDGE/TERM switch to appropriate setting (see Paragraph 4.04).
4) Set 600 Ω/900 Ω switch to match line impedance.

5) Set NORM/REV switch to NORM to send.
6) Set NORM/REV switch to REV to receive.
7) Set 4W/2W switch to 2W.
8) Set NORM/RETURN LOSS switch to NORM.
9) If sending over a dial-up network employing 2600 Hz SF (single frequency) signaling, set SF SKIP switch to in position. Otherwise, the dialed connection may be lost during test.
10) Connect 2-wire line to 2W (NORM-SEND) jack.

4.09 Since the Basic Unit is equipped with electronic hold circuits for both SEND and REC jacks, the NORM-REC jack may be used for 2-wire interface. This allows the Basic Unit to be used in a double 2-wire mode as required when performing a delay measurement in either the Forward or Return Reference mode on 2-wire facilities.

D. 4-Wire

4.10 To interface with 4-wire lines, proceed as follows:
1) Set DIAL/TK switch to out position.
2) Set HOLD switch to out position.
3) Set BRIDGE/TERM switch to appropriate setting (see Paragraph 4.04).
4) Set 600 Ω/900 Ω switch to match line impedance.
5) Set NORM/REV switch to NORM.
6) Set 4W/2W switch to 4W.
7) Set NORM/RETURN LOSS switch to NORM.
8) Set SF SKIP switch to in position if SF signaling circuit is in the path.
9) Connect send line to NORM-SEND jack.
10) Connect receive line to NORM-REC jack.

E. Dial/Talk

4.11 The Basic Unit is equipped with a versatile Dial/Talk circuit that enables a lineman's handset (butt-in) or a headset to be used in either 2-wire or 4-wire operation.

4.12 To call on a single 2-wire wet line, proceed as follows:
1) If sending over a dial-up network employing 2600 Hz SF signaling, set SF SKIP switch to in position. Otherwise, the dialed connection may be lost during test.
2) Set HOLD switch to out position.
3) Set BRIDGE/TERM switch to BRIDGE.
4) Set 600 Ω/900 Ω switch to match line impedance.
5) Set NORM/REV switch to REV.
6) Set 4W/2W switch to 2W.
7) Connect the line to 2W (REV-REC) jack.
8) Connect lineman's handset to DIAL/TK jack.
9) Set DIAL/TK switch to in position.
10) Dial up using the handset.
11) After the dialed connection has been established, set HOLD switch to in position.
12) To return to normal testing mode, set DIAL/TK switch to out position.
13) Set NORM/REV switch to NORM to send.
14) Set NORM/REV switch to REV to receive.
15) If Basic Unit is to be used as termination for receive line, set BRIDGE/TERM switch to TERM.

4.13 To answer on a single 2-wire wet line, proceed as follows:
1) If sending over a dial-up network employing 2600 Hz SF signaling, set SF SKIP switch to in position. Otherwise, the dialed connection may be lost during test.
2) Set HOLD switch to out position.
3) Set BRIDGE/TERM switch to BRIDGE.
4) Set 600 Ω/900 Ω switch to match line impedance.
5) Set NORM/REV switch to REV.
6) Set 4W/2W switch to 2W.
7) Connect the line to 2W (REV-REC) jack.
8) Connect lineman's handset to the DIAL/TK jack. Put the handset to "on-hook".
9) Set DIAL/TK switch to in position.
10) Answer using the handset.

11) After the dialed connection has been established, set HOLD switch to in position.
12) To return to normal testing mode, set DIAL/TK switch to out position.
13) Set NORM/REV switch to NORM to send.
14) Set NORM/REV switch to REV to receive.
15) If Basic Unit is to be used as termination for receive line, set BRIDGE/TERM switch to TERM.

4.14 The handset may remain plugged into the DIAL/TK jack without affecting the measurement in process. If it is desired to return to talk mode while the measurement is in progress, set the DIAL/TK switch to in position and NORM/REV to REV.

4.15 To call on a double 2-wire wet line, proceed as follows:
1) If sending over a dial-up network employing 2600 Hz SF signaling, set SF SKIP switch to in position. Otherwise, the dialed connection may be lost during test.
2) Set HOLD switch to out position.
3) Set BRIDGE/TERM switch to BRIDGE.
4) Set 600 Ω/900 Ω switch to match line impedance.
5) Set NORM/REV switch to NORM.
6) Set 4W/2W switch to 2W.
7) Connect send line to NORM-SEND jack.
8) Connect receive line to NORM-REC jack.
9) Connect lineman's handset to the DIAL/TK jack.
10) Set DIAL/TK switch to in position. The handset is now connected to the NORM-REC line.
11) Dial using the handset.
12) After the dialed connection has been established, set HOLD switch to in position.
13) Set NORM/REV switch to REV. The handset is now connected to the REV-REC line.
14) Listen for a dial tone. If it is not present, put the handset to "on-hook" and then back to "off-hook" to obtain a dial tone.
15) Dial using the handset.
16) After the dialed connection has been established, set DIAL/TK switch to out position to return to normal testing mode.
17) Set NORM/REV switch to NORM position.
18) If the Basic Unit is to be used as termination for receive line, set BRIDGE/TERM switch to TERM.

4.16 To answer on a double 2-wire wet line, proceed as follows:
1) If sending over a dial-up network employing 2600 Hz SF signaling, set SF SKIP switch to in position. Otherwise, the dialed connection may be lost during test.
2) Set HOLD switch to out position.
3) Set BRIDGE/TERM switch to BRIDGE.
4) Set 600 Ω/900 Ω switch to match line impedance.
5) Set NORM/REV switch to REV.
6) Set 4W/2W switch to 2W.
7) Connect send line to NORM-SEND jack.
8) Connect receive line to NORM-REC jack.
9) Connect lineman's handset to the DIAL/TK jack. Put the handset to "on-hook".
10) Set the DIAL/TK switch to in position. The handset is now connected to REV-REC line.
11) Answer using the handset.
12) After the dialed connection has been established, set HOLD switch to in position.
13) Set NORM/REV switch to NORM. The handset is now connected to NORM-REC line. Return the handset to "on-hook".
14) Answer using the handset.
15) After the dialed connection has been established, set DIAL/TK switch to out position to return to normal testing mode.
16) If the Basic Unit is to be used as termination for receive line, set BRIDGE/TERM switch to TERM.

4.17 The handset may remain plugged into the DIAL/TK jack without affecting the measurement in progress. If it is desired to return to talk mode while the measurement is in progress, set DIAL/TK switch to in position and NORM/REV to REV.

4.18 To talk or listen on a 2-wire dry line, proceed as follows using either a lineman's handset or a headset.

1) Set SF SKIP switch to in position if SF signaling circuit is in the path.
2) Set HOLD switch to out position.
3) Set BRIDGE/TERM switch to appropriate setting (see Paragraph 4.04).
4) Set 600 Ω/900 Ω switch to match line impedance.
5) Set NORM/REV switch to NORM to talk.
6) Set NORM/REV switch to REV to listen.
7) Set 4W/2W switch to 4W.
8) Set NORM/RETURN LOSS switch to NORM.
9) Connect the line to 2W (NORM-SEND) jack.
10) Connect a lineman's handset to DIAL/TK jack or a headset to HDST jacks.
11) Set DIAL/TK switch to in position.
12) To return to normal testing mode, set DIAL/TK switch to out position.
13) Set NORM/REV switch to NORM to send.
14) Set NORM/REV switch to REV to receive.

4.19 On 2-wire dry line, talk is possible from send to receive only and NORM/REV switch should be used to coordinate talk and listen.

4.20 To talk on 4-wire dry lines, proceed as follows using either a lineman's handset or a headset.

1) Set SF SKIP switch to in position if SF signaling circuit is in the path.
2) Set HOLD switch to out position.
3) Set BRIDGE/TERM switch to appropriate setting (see Paragraph 4.04).
4) Set 600 Ω/900 Ω switch to match line impedance.
5) Set NORM/REV switch to NORM.
6) Set 4W/2W switch to 4W.
7) Set NORM/RETURN LOSS switch to NORM.
8) Connect send line to NORM-SEND jack.
9) Connect receive line to NORM-REC jack.
10) Connect a lineman's handset to DIAL/TK jack or a headset to HDST jacks.
11) Set DIAL/TK switch to in position.
12) To return to normal testing mode, set DIAL/TK switch to out position.

4.21 When DIAL/TK switch is set to out position on dry lines, the handset and the headset may be left plugged in to monitor receive signal without affecting measurement. When DIAL/TK switch is set to in position, the headset can be used to talk and listen, while the handset can be used to talk only. However, the handset can be used to monitor receive signal at any time by connecting it to the left HDST jack.

5. LEVEL MEASUREMENT

5.01 This section describes the operating procedures for the Model 3901 Basic Unit when performing the following:

- Absolute Level Measurement
- Relative Level Measurement

5.02 Overrange and underrange indications are provided to alert the operator when the level of the signal being measured exceeds the measurement capability of the Basic Unit.

5.03 Selection of 60 Hz filtering and damping during a level measurement is also discussed in this section. Refer to Figure 6 while performing the following procedures.

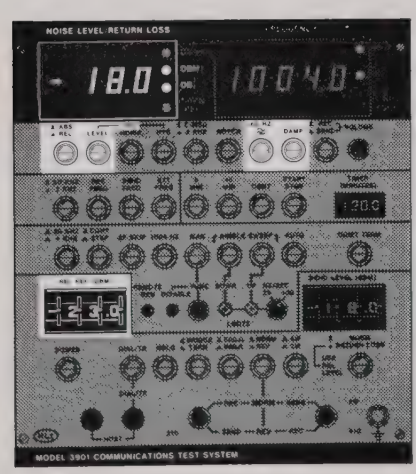

Figure 6. Level Measurement Controls and Displays

A. Absolute Level Measurement

5.04 To perform an absolute level measurement, proceed as follows:

1) Set ABS/REL switch to ABS.
2) Set REC-LEVEL switch to in position.
3) Refer to Section 4 for line interface information.
4) Read the absolute level directly from the NOISE/LEVEL/RETURN LOSS display. The proper unit of measurement is indicated by the DBM indicator to the right of the display.

B. Relative Level Measurement

5.05 To perform a relative level measurement, proceed as follows:

1) Set ABS/REL switch to REL.
2) Set REC-LEVEL switch to in position.
3) Set REL REF (DBM) thumbwheel switches to the desired reference level (e.g., TLP, Data Level, etc.).
4) Refer to Section 4 for line interface information.
5) Read the relative level directly from the NOISE/LEVEL/RETURN LOSS display. The proper unit of measurement is indicated by the DB indicator to the right of the display.

C. 60 Hz Filtering

5.06 The Basic Unit contains a 60 Hz high-pass filter that can be selected by setting the 60 HZ ≈ switch to in position. Selecting the filter will reduce the effects of power line interference on the level measurements.

D. Damping

5.07 If the reading fluctuates due to noise or low repetition rate of the signal, it can be damped by setting the DAMP switch to in position.

E. Overrange and Underrange Indications

5.08 If the received signal exceeds the measurement capabilities of the Basic Unit, one of the following overrange or underrange indications will occur:

- If the level goes above +10 dBm or +10 dB, the display will blank with the exception of the positive sign, indicating an overrange condition.
- If the level goes below −80.0 dBm or −80.0 dB, the display will blank with the exception of the negative sign, indicating an underrange condition.

6. NOISE MEASUREMENT

6.01 This section describes the operating procedures for the Model 3901 Basic Unit when performing the following:

- Absolute Noise Measurement
- Relative Noise Measurement
- Absolute Noise-to-Ground Measurement
- Relative Noise-to-Ground Measurement

This section also contains selection information for the following filters:

- C-Message
- 3 kHz Flat
- Notch
- 60 Hz High Pass

6.02 Damping may be selected for all noise measurements. Overrange and underrange indications are provided to alert the operator when the level of the signal being measured exceeds the measurement capabilities of the Basic Unit.

6.03 When making low-level noise or noise-to-ground measurements, it is recommended that the generator be put in the quiet termination mode by setting the QUIET TERM switch to in position. (Refer to Section 9.) Refer to Figure 7 while performing the following procedures.

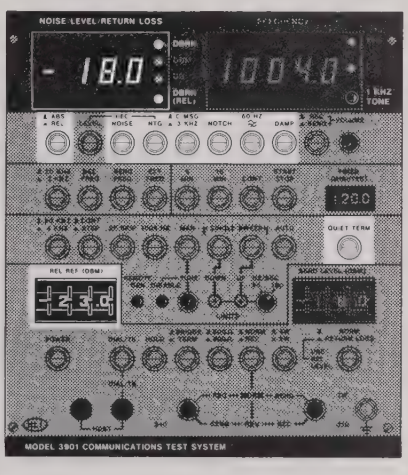

Figure 7. Noise Measurement Controls and Displays

A. Absolute Noise Measurement

6.04 To perform an absolute noise measurement, proceed as follows:

1) Set ABS/REL switch to ABS.
2) Set REC-NOISE switch to in position.
3) Refer to Section 6.E. for filter selection.
4) Refer to Section 4 for line interface information.
5) Read the absolute noise level directly from the NOISE/LEVEL/RETURN LOSS display. The proper unit of measurement is indicated by the DBRN indicator to the right of the display.

B. Relative Noise Measurement

6.05 To perform a relative noise measurement, proceed as follows:

1) Set ABS/REL switch to REL.
2) Set REC-NOISE switch to in position.
3) Refer to Section 6.E. for filter selection.
4) Refer to Section 4 for line interface information.
5) Set REL REF (DBM) thumbwheel switches to the desired reference (e.g., TLP, Data Level, etc.) level from +9.9 to −39.9 dBm.
6) Read the relative noise level directly from the NOISE/LEVEL RETURN LOSS display. The proper unit of measurement is indicated by the DBRN (REL) indicator to the right of the display.

Note: 90 dBrn (Rel) is equivalent to 0 dB.

C. Absolute Noise-to-Ground Measurement

6.06 To perform an absolute noise-to-ground measurement, proceed as follows:

1) Set ABS/REL switch to ABS.
2) Set REC-NTG switch to in position.

3) Refer to Section 6.E. for filter selection.
4) Refer to Section 4 for line interface information.
5) Read the absolute noise-to-ground level directly from the NOISE/LEVEL/RETURN LOSS display. The proper unit of measurement is indicated by the DBRN indicator to the right of the display. The level is referenced to 600 Ω in noise-to-ground measurements.

Note: Do not add a correction factor to the reading, as this is done internally.

D. Relative Noise-to-Ground Measurement

6.07 To perform a relative noise-to-ground measurement, proceed as follows:

1) Set ABS/REL switch to REL.
2) Set REC-NTG switch to in position.
3) Refer to Section 6.E. for filter selection.
4) Refer to Section 4 for line interface information.
5) Set REL REF (DBM) thumbwheel switches to the desired reference (e.g., TLP, Data Level, etc.) level from +9.9 to −39.9 dBm.
6) Read the relative noise-to-ground level directly from the NOISE/LEVEL/RETURN LOSS display. The proper unit of measurement is indicated by the DBRN (REL) indicator to the right of the display.

Note: Do not add a correction factor to the reading, as this is done internally. 90 dBrn (Rel) is equivalent to 0 dB.

E. Noise Filter Selection

6.08 When performing a noise or noise-to-ground measurement, select one or more of the following filters, as required:

- C-Message or 3 kHz Flat
- Notch
- 60 Hz High Pass

6.09 In all noise or noise-to-ground measurement modes and in the absence of plug-in noise filter modules, either the C-Message or the 3 kHz filter will always be in the circuit depending on the setting of the C-MSG/3 KHZ switch. If C-Message weighting is desired, set C-MSG/3 KHZ switch to C-MSG; if 3 kHz flat filtering is desired, set C-MSG/3 KHZ switch to 3 KHZ.

6.10 The Basic Unit contains a notch filter that can be selected by setting the NOTCH switch to in position. The notch filter will attenuate all frequencies in the band from 995 - 1025 Hz by at least 50 dB.

6.11 To reduce the effects of power line interference, a 60 Hz high-pass filter can be selected by setting the 60 HZ≳ switch to the in position. The 60 Hz filter may be selected in all noise or noise-to-ground measurement modes.

F. Damping

6.12 If the reading fluctuates due to noise or low repetition rate of the signal, it can be damped by setting the DAMP switch to in position.

G. Overrange and Underrange Indications

6.13 If the received noise level exceeds the measurement capabilities of the Basic Unit, one of the following overrange or underrange indications will occur:

- If the level goes above +100 dBrn or +100 dBrn (Rel) for noise, or above +130 dBrn or +130 dBrn (Rel) for noise-to-ground, the display will blank with the exception of a positive sign, indicating an overrange condition.
- If the level goes below +10 dBrn or +10 dBrn (Rel) for noise, or below +40 dBrn or +40 dBrn (Rel) for noise-to-ground, the display will blank with the exception of a negative sign, indicating an underrange condition.

H. Holding Tone Indicator

6.14 For easy verification of the presence of a holding tone when making noise-with-tone measurements, the 1 KHZ TONE LED is provided. For more detailed discussion of this feature, refer to Section 12.

7. FREQUENCY MEASUREMENT

7.01 This section describes the operating procedures for the Model 3901 Basic Unit frequency counter when performing the following:

- Receive Frequency Measurement
- Send Frequency Measurement
- External Frequency Measurement

Frequencies from 40 Hz to 19.999 kHz can be measured in two switch-selectable ranges. The frequency counter contains automatic overrange and underrange indications which occur when the applied frequency is outside the measurement limits. Refer to Figure 8 while performing the following procedures.

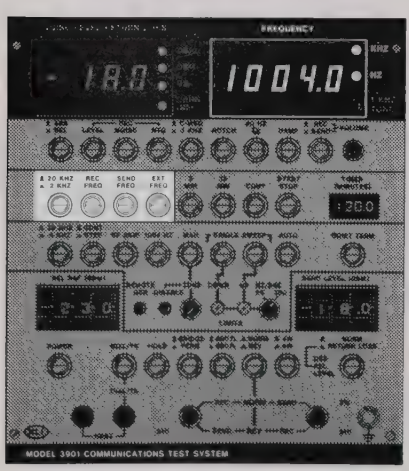

Figure 8. Frequency Measurement Controls and Displays

A. Receive Frequency Measurement

7.02 To perform a receive frequency measurement, proceed as follows:

1) Set 20 KHZ/2 KHZ switch to desired frequency range.
2) Set REC FREQ switch to in position.
3) Refer to Section 4 for line interface information.
4) Read the receive frequency directly from the FREQUENCY display.

B. Send Frequency Measurement

7.03 To perform a send frequency measurement, proceed as follows:

1) Set 20 KHZ/2 KHZ switch to desired frequency range.
2) Set SEND FREQ switch to in position.
3) Read send frequency directly from the FREQUENCY display.

Note: Send frequency can be measured in QUIET TERM mode, which permits frequency set up before going on-line.

C. External Frequency Measurement

7.04 To perform a measurement of an external frequency applied to the EXT-T, -R, -S five-way binding posts on the rear panel, proceed as follows:

1) Set 20 KHZ/2 KHZ switch to desired frequency range.
2) Set EXT FREQ switch to in position.
3) Read external frequency directly from the FREQUENCY display.

7.05 The external input is extremely useful when performing third-point delay measurements. Refer to the DELAY Module Operating Manual (3912-M20) for detailed instructions.

D. Overrange and Underrange Indications

7.06 If the applied frequency exceeds the measurement capabilities of the Basic Unit, one of the following overrange or underrange indications will occur:

- If the frequency goes above 1999.9 Hz in the 2 kHz range, or above 19.999 kHz in the 20 kHz range, the FREQUENCY display will blank with the exception of a positive sign, indicating an overrange condition.
- If the frequency goes below 40 Hz in either the 2 kHz or 20 kHz range, the FREQUENCY display will blank with the exception of a negative sign, indicating an underrange condition.

8. SINE WAVE RETURN LOSS MEASUREMENT

8.01 This section describes the operating procedures for the Model 3901 Basic Unit when performing 2-wire and 4-wire return loss measurements. Return loss is indicated by positive (+) dB for 2-wire or 4-wire measurements. Refer to Figure 9 when performing the following procedures.

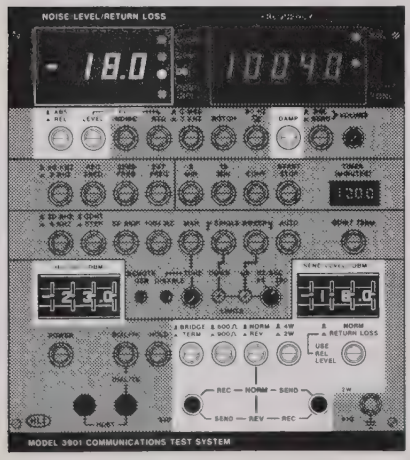

Figure 9. Sine Wave Return Loss Measurement Controls and Displays

A. 2-Wire Return Loss Measurement

8.02 To perform a 2-wire return loss measurement, proceed as follows:

1) Set ABS/REL switch to REL.
2) Set REC-LEVEL switch to in position.
3) Set DAMP switch to in position.
4) Set BRIDGE/TERM switch to TERM to use the internal standard impedance, or set the switch to BRIDGE and connect an external standard impedance to the NORM-REC jack.
5) Set 600 Ω/900 Ω switch to match line impedance if the internal standard impedance is being used. If external standard impedance is being used, omit this step.
6) Set NORM/REV switch to NORM.
7) Set 4W/2W switch to 2W.
8) Set NORM/RETURN LOSS switch to RETURN LOSS.
9) Refer to Section 10 for frequency set-up instructions.
10) Set SEND LEVEL (DBM) thumbwheel switches for the desired output level. ***Do not exceed 0.0 dBm.***
11) Set REL REF (DBM) thumbwheel switches to obtain a NOISE/LEVEL/RETURN LOSS display reading of 0.0 DB, with the line under test not connected.
12) Connect the line under test to the NORM-SEND jack and read the return loss directly from the NOISE/LEVEL/RETURN LOSS display. The proper unit of measurement is indicated by the DB indicator to the right of the display.

B. 4-Wire Return Loss Measurement

8.03 To perform a 4-wire return loss measurement, proceed as follows:

1) Set ABS/REL switch to REL.
2) Set REC-LEVEL switch to in position.
3) Set DAMP switch to in position.
4) Set BRIDGE/TERM switch to TERM.
5) Set 600 Ω/900 Ω switch to match line impedance.
6) Set NORM/REV switch to NORM.
7) Set 4W/2W switch to 4W.
8) Set NORM/RETURN LOSS switch to RETURN LOSS.
9) Connect the send and receive lines to the NORM-SEND, NORM-REC jacks, respectively.
10) Refer to Section 10 for frequency set-up instructions.
11) Set SEND LEVEL (DBM) thumbwheel switches for the desired output level. ***Do not exceed 0.0 dBm.***
12) With the 2-wire side of the hybrid opened, set REL REF (DBM) thumbwheel switches to obtain a NOISE/LEVEL/RETURN LOSS display reading of 0.0 DB.
13) Terminate 2-wire side of the hybrid and read the return loss directly from the NOISE/LEVEL/RETURN LOSS display. The proper unit of measurement is indicated by the DB indicator to the right of the display.

9. SEND LEVEL SETUP

9.01 This section describes the send level setup procedure for the Model 3901 Basic Unit. Refer to Figure 10 when performing the following setup procedure.

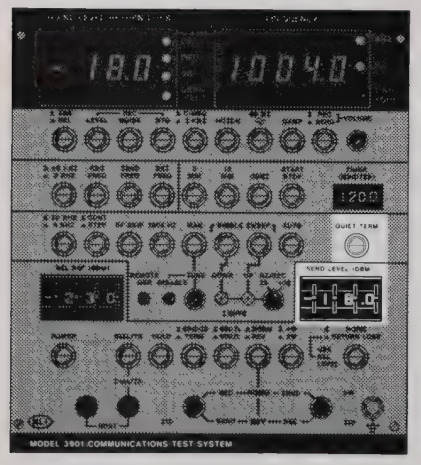

Figure 10. Send Level Setup Controls

A. Send Level Adjustment

9.02 Send level is adjustable in 0.1 dB steps from +9.9 to −39.9 dBm. It is set using the SEND LEVEL (DBM) thumbwheel switches which display proper send level to a matched termination.

B. Quiet Termination

9.03 When performing low-level measurements or noise-without-tone-measurements, it is recommended that the basic unit generator be turned off by setting the QUIET TERM switch to in position. (Quiet Termination mode overrides all other generator functions.)

10. SEND FREQUENCY SETUP

10.01 This section describes the send frequency setup procedures for the Model 3901 Basic Unit. The Basic Unit provides the following features and modes of operation:

- 40 - 4000 Hz or 200 - 20,000 Hz
- 100 Hz Lock with +4 Hz offset
- SF Skip
- Fixed 1004.0 Hz
- Manual Tune
- Single Sweep Down
- Single Sweep Up
- Automatic Sweep
- Quiet Termination

Refer to Figure 11 when performing the following send frequency setup procedures.

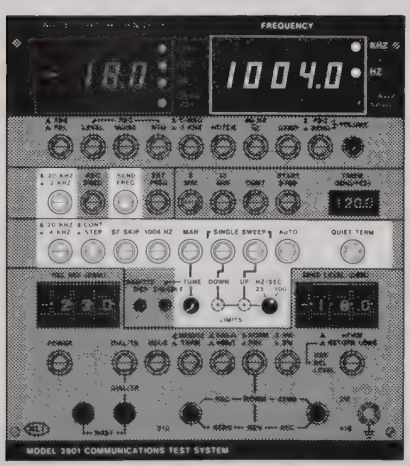

Figure 11. Send Frequency Setup Controls and Displays

A. Fixed 1004.0 Hz

10.02 To send 1004.0 Hz, set 1004 HZ switch to in position.

B. Manual Tune

10.03 To manually tune the basic unit generator, proceed as follows:

1) Set 20 KHZ/2 KHZ switch to 20 KHZ.
2) Set SEND FREQ switch to in position.
3) Set 20 KHZ/4 KHZ switch to desired range.
4) Set CONT/STEP switch to desired mode.
5) Set SF SKIP switch to in position on circuits employing SF signaling.
6) Set MAN switch to in position.
7) Adjust MAN TUNE knob to desired frequency while observing the FREQUENCY display.

C. Single Sweep Up, Down

10.04 For single sweep operation, proceed as follows:

1) Set 20 KHZ/2 KHZ switch to 20 KHZ.
2) Set SEND FREQ switch to in position.
3) Set 20 KHZ/4 KHZ switch to desired range.
4) Set CONT/STEP switch to desired mode.
5) Set SF SKIP switch to in position on circuits employing SF signaling.
6) Set HZ/SEC knob fully clockwise.
7) Set SINGLE SWEEP DOWN switch to in position.
8) Adjust DOWN LIMIT pot to desired lower frequency limit while reading the FREQUENCY display.
9) Set SINGLE SWEEP UP switch to in position.
10) Adjust UP LIMIT pot to desired upper frequency limit while reading the FREQUENCY display.
11) Set HZ/SEC knob to desired sweep rate. For single sweep operation, alternately set SINGLE SWEEP UP and SINGLE SWEEP DOWN switches to in position.

D. Automatic Sweep

10.05 For automatic sweep operation, proceed as follows:

1) Set 20 KHZ/2 KHZ switch to 20 KHZ.
2) Set SEND FREQ switch to in position.

3) Set 20 KHZ/4 KHZ switch to desired range.
4) Set CONT/STEP switch to desired mode.
5) Set SF SKIP switch to in position for circuits employing SF signaling.
6) Set HZ/SEC knob to fully clockwise position.
7) Set SINGLE SWEEP DOWN switch to in position.
8) Adjust DOWN LIMIT pot to desired lower frequency limit while reading the FREQUENCY display.
9) Set SINGLE SWEEP UP switch to in position.
10) Adjust UP LIMIT pot to desired upper frequency limit while reading the FREQUENCY display.
11) Set AUTO switch to in position.
12) Set HZ/SEC knob to desired sweep rate.

E. Quiet Termination

10.06 It is possible to set up send frequency in quiet termination mode, even though there is no signal being transmitted. This permits frequency setup prior to putting the signal on line.

11. TIMER OPERATION

11.01 This section describes use and operational features of the electronic timer on the Model 3901 Basic Unit. The timer is used for setting and measuring the time interval for totalizing measurements such as impulse noise counts. The timer also provides an interrupt indication to alert the operator that a change affecting the totalizing measurement has been made before the test period was finished. Refer to Figure 12 during following procedures.

11.02 Switches on the Basic Unit should be set for the desired measurement parameters before the measurement interval is started. As described in Paragraph 11.05, a timer interrupt indication may occur if these parameters are changed during a measurement. Module parameters should be set up prior to the initiation of the test so that no changes are necessary during the test.

Note: The timer cannot be activated unless an appropriate plug-in module is turned on.

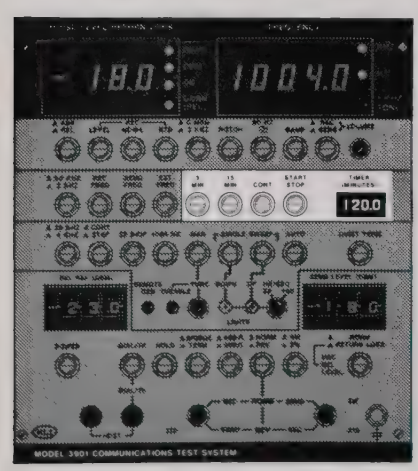

Figure 12. Timer Controls and Display

11.03 To start the timer, proceed as follows:

1) Select timer interval by setting desired switch (5 MIN, 15 MIN, CONT) to in position.
2) Set the basic unit switches for the desired measurement parameters.
3) Set up parameters on plug-in module(s) to be used. Refer to the operating manual for the appropriate module(s).
4) Turn on the desired plug-in module(s).
5) To start the timer, momentarily press START/STOP switch.
6) To stop the timer, press START/STOP switch again.

11.04 If the timer interval is set to either 5 MIN or 15 MIN, the timer will automatically time out after the desired interval has elapsed. In CONT mode, the timer will count past 999.9 minutes if not stopped by activating START/STOP switch.

A. Interrupt Indication

11.05 The basic unit TIMER (MINUTES) display will flash at a 1 Hz rate to alert the operator that the totalizing measurement has been interrupted because a change in measurement parameters has occurred.

11.06 A timer interrupt indication will occur if any of the following switch settings are changed during an impulse noise measurement.

- ABS/REL
- NTG
- C-MSG/3 KHZ
- NOTCH
- 60 HZ
- 5 MIN
- 15 MIN
- CONT
- START/STOP

11.07 A timer interrupt indication will occur if any of the following switch settings are changed during a hits and jitter measurement.

- NTG
- 5 MIN
- 15 MIN
- CONT
- START/STOP

11.08 Activation of other plug-in modules while any totalizing measurement is in progress may also cause a timer interrupt indication to occur.

11.09 Changes to the Basic Unit relative reference level settings or changes to the switch settings on plug-in module(s) during a measurement will not interrupt operation of the timer.

12. INDICATORS

12.01 This section describes the function of the Model 3901 Basic Unit LED indicators, and the operating conditions which will cause them to turn on and off. Shown in Figure 13 are three LED indicators other than the ones already discussed in various measurement modes.

- 1 KHZ TONE
- TUNE DISABLE
- REMOTE GEN

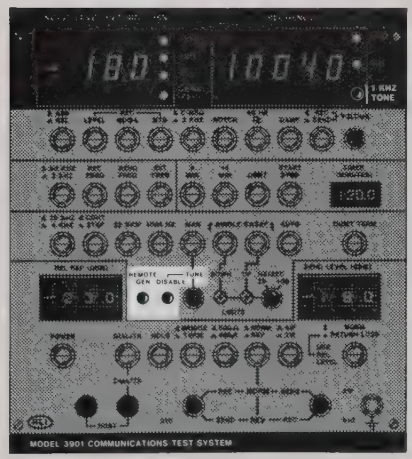

Figure 13. Basic Unit LED Indicators

A. 1 kHz Tone

12.02 The 1 KHZ TONE indicator is a green LED in the corner of the FREQUENCY display window. The LED will be on only when both of the following conditions are satisfied:

- Receive frequency is between 990 and 1030 Hz
- Receive level is between +10 and 40 dBm

The 1 KHZ TONE indicator will flash on and off if the receive level is within the specified limits, and the receive frequency is within one of the following bands:

- 980 to 990 Hz
- 1030 to 1040 Hz

The 1 KHZ TONE indicator will be off if any of the following conditions exist:

- Receive frequency is below 980 Hz
- Receive frequency is above 1040 Hz
- Receive level is above +10 dBm
- Receive level is below −40 dBm

B. Tune Disable

12.03 The TUNE DISABLE indicator will be on whenever the basic unit signal generator is being remotely tuned. When the indicator is on, the following generator switches and controls have no effect on the output signal:

- MAN
- SINGLE SWEEP DOWN, UP
- AUTO
- MAN TUNE
- UP, DOWN LIMIT
- HZ/SEC

The Basic Unit will however, maintain control of the following switches, even when the TUNE DISABLE indicator is on:

- 20 KHZ/4 KHZ
- CONT/STEP
- SF SKIP
- 1004 HZ
- QUIET TERM

C. Remote Generator

12.04 The REMOTE GEN indicator will be on whenever a plug-in module containing its own generator is activated. When the indicator is on, the basic unit generator is not providing an output signal. Therefore, the following basic unit generator switches and controls have no effect on the output signal:

- 20 KHZ/4 KHZ
- CONT/STEP
- SF SKIP
- 1004 HZ
- MAN TUNE
- AUTO
- SINGLE SWEEP DOWN, UP

13. AUDIO MONITOR

13.01 This section describes the operation of the Model 3901 Basic Unit audio monitor.

13.02 The Basic Unit is equipped with a built-in speaker (on the rear panel) and a REC/SEND switch which allows the operator to listen to either the receive or the send signal. Adjust the VOLUME control knob for comfortable listening level. Figure 14 shows the REC/SEND switch and VOLUME control knob.

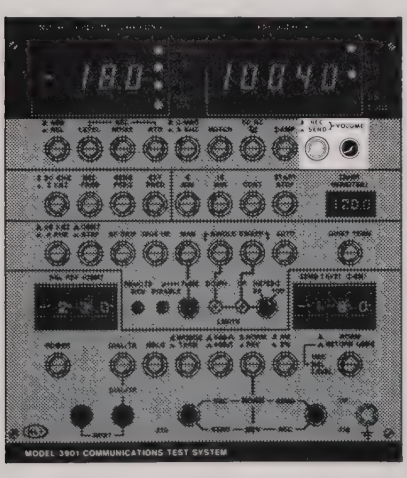

Figure 14. Audio Monitor Control

14. REAR PANEL FACILITIES

14.01 This section describes the facilities located on the rear panel. Rear panel connectors, as shown in Figure 15, provide convenience outputs and facilitate operation when the Basic Unit is rack mounted. The following input and output signals are available:

- Frequency output (dc voltage proportional to frequency)
- DB Level output (dc voltage proportional to level)
- Delay output (dc voltage proportional to delay)*
- Demodulated Phase Jitter Waveform*
- Demodulated Amplitude Jitter Waveform*
- Monitor output
- Receive and Send (parallel to front panel receive and send jacks) five-way binding post connections.

*Contingent upon presence of appropriate modules.

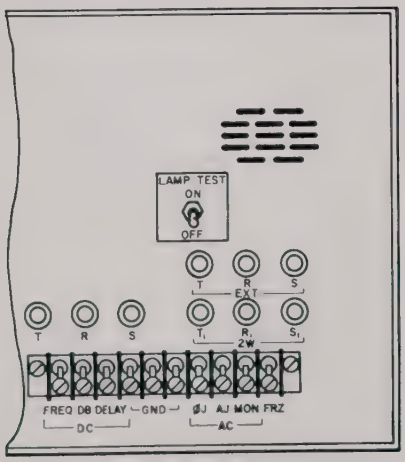

Figure 15. Rear Panel Facilities

Lamp Test and Display Freeze are two more functions provided on the rear panel. Input connectors for measuring an external frequency (useful in third-point delay measurements) are also provided.

A. Lamp Test

14.02 The LAMP TEST switch provides the means to verify operation of all digital displays and indicators on the Model 3901 Basic Unit and plug-in modules that are on. Setting the LAMP TEST switch to ON turns on all segments of each LED readout and indicator on the Basic Unit and the enabled modules.

B. Display Freeze

14.03 Display readings on the Basic Unit and any enabled plug-in module(s) can be frozen for ease of observation by applying chassis ground through a dry contact closure to the barrier-strip terminal marked FRZ.

> **WARNING:** To avoid damaging the unit due to large off-ground (foreign) voltages, the ground used for the Freeze must be from one of the GND terminals provided on the rear panel barrier strip.

14.04 When the Basic Unit is placed in the Freeze mode, the displayed information is not affected by changes in the input signal. However, if any Basic Unit or plug-in module control settings are changed, the displayed information may also change.

C. Inputs

14.05 The five-way binding posts identified as 2W-T_1, R_1 and S_1 are connected in parallel with the basic unit NORM-SEND front panel jack, and the five-way binding posts identified as T, R and S are connected in parallel with the NORM-REC front panel jack. These rear panel connectors may be used in an identical manner to the front panel jacks as described in Section 4, LINE INTERFACES.

14.06 There are also five-way binding post input connectors, identified as EXT-T, -R and -S, that may be used for counting fre-

quency. This input, with a bridging impedance in excess of 10 kΩ for frequency higher than 1 kHz, provides a frequency measurement capability in excess of 4 kHz with signal levels as low as −40 dBm. It may be used, as a convenience, to measure the frequency of any signal within the specified limits and to perform third-point delay measurement.

D. DC Outputs

14.07 The following dc outputs are provided with a source impedance of 2 kΩ and are available on the rear panel barrier strip terminals:

- DC - FREQ
- DC - DB
- DC - DELAY

14.08 The FREQ is an analog output whose voltage varies proportionally with the frequency being measured. The scale factor is 2 V/kHz when the Basic Unit generator is set to 4 kHz range, and 0.4V/kHz in 20 kHz range.

14.09 The DB is an analog output whose voltage varies proportionally with the level of the signal being measured. The scale factor is 1 V/10 dB with zero volts corresponding to the following table:

	ABS	REL
LEVEL	0 dBm	0 dB
NOISE	+90 dBrn	+90 dBrn (REL)
NOISE-TO-GROUND	+120 dBrn	+120 dBrn (REL)

14.10 The DELAY is an analog output whose voltage varies proportionally with the delay being measured. The scale factor is 0.5 V/1000 μsec with zero volts corresponding to zero microseconds. This output is only available when the appropriate plug-in module is installed.

E. AC Outputs

14.11 The following ac outputs are provided with a source impedance of 2 kΩ and are available on the rear panel barrier strip terminals:

- AC - ØJ
- AC - AJ
- AC - MON

14.12 The ØJ output is demodulated phase jitter waveform whose scale factor is 1 V/10° peak-to-peak jitter. This output is only available when the appropriate plug-in module is installed.

14.13 The AJ output is demodulated amplitude jitter waveform whose scale factor is 1 V/10% peak jitter. This output is only available when the appropriate plug-in module is installed.

14.14 The MON output carries the same audio signal used to drive the monitor speaker, but the VOLUME knob has no effect on this output.

15. SELF-TEST

15.01 This section describes the procedures for self-testing the Model 3901 Basic Unit. These procedures are to be used for self-test purposes only, and are not intended for calibration. (Calibration is covered in Service Manual, 3901-M30.) A looping cord and two jumper wires are required to do self-check. Perform the following self-check procedures in sequence.

A. Initial Switch Settings

WARNING: Check to see that the 115/230 volt selector switch, located on the rear panel, is set to the correct position.

Proceed as follows:

1) Connect the ac power cord to the rear panel receptacle and power source.
2) Connect looping cord from the NORM-REC jack to the NORM-SEND jack.
3) Set REC-LEVEL switch to in position.
4) Set REC FREQ switch to in position.
5) Set 5 MIN switch to in position.
6) Set 1004 HZ switch to in position.
7) Adjust REL REF (DBM) thumbwheel switches for +00.0.
8) Adjust SEND LEVEL (DBM) thumbwheel switches for +00.0.
9) Set BRIDGE/TERM switch to TERM.
10) Set all remaining switches to out position.
11) Set POWER switch to in position.
12) Adjust VOLUME control for a comfortable level.

B. Level/Noise Check

15.02 To perform the level/noise checks, proceed as follows:

1) Observe that the NOISE/LEVEL/RETURN LOSS display reads 0.0 ±0.2 DBM.
2) Observe that 1 KHZ TONE LED is on.
3) Set ABS/REL switch to REL.
4) Observe that the NOISE/LEVEL/RETURN LOSS display reads 0.0 ±0.2 DB.
5) Set REC-NOISE switch to in position.
6) Observe that the NOISE/LEVEL/RETURN LOSS display reads +90 ±1 DBRN (REL).
7) Set ABS/REL switch to ABS.
8) Observe that the NOISE/LEVEL/RETURN LOSS display reads +90 ±1 DBRN.
9) Set REC-NTG switch to in position.
10) Connect the five-way binding posts labeled T and S on the rear panel with a jumper wire.
11) Observe that the NOISE/LEVEL/RETURN LOSS display reads +84 ±2 DBRN.
12) Remove the jumper wire installed in step 10.
13) Set REC-LEVEL switch to in position.
14) Set QUIET TERM switch to in position.
15) Observe that the NOISE/LEVEL/RETURN LOSS display blanks with the exception of the negative sign.
16) Set QUIET TERM switch to out position.
17) Set BRIDGE/TERM switch to BRIDGE.
18) Observe that the NOISE/LEVEL/RETURN LOSS display reads 6.0 ±0.2 DBM.
19) Adjust SEND LEVEL (DBM) thumbwheel switches for +05.0.
20) Observe that the NOISE/LEVEL/RETURN LOSS display blanks with the exception of the positive sign.

C. Frequency Counter Check

15.03 To perform the frequency counter check, proceed as follows:

1) Set BRIDGE/TERM switch to TERM.
2) Observe that the FREQUENCY display reads 1.004 ±0.001 KHZ.
3) Set QUIET TERM switch to in position.
4) Observe that the FREQUENCY display blanks with the exception of negative sign.
5) Set SEND FREQ switch to in position.
6) Observe that the FREQUENCY dis-

play reads 1.004 ±0.001 KHZ.
7) Set 20 KHZ/2 KHZ switch to 2 KHZ.
8) Observe that the FREQUENCY display reads 1004.0 ±0.1 HZ.
9) Connect the five-way binding posts laveled T and EXT-T with a jumper wire, and R and EXT-R with a jumper wire.
10) Set EXT FREQ switch to in position.
11) Observe that the FREQUENCY display blanks with the exception of the negative sign.
12) Set QUIET TERM switch to out position.
13) Observe that the FREQUENCY display reads 1004.0 ±0.1 HZ.
14) Remove the jumper wires installed in step 9.

D. Generator Check

15.04 To perform the generator check, proceed as follows:
1) Set 20 KHZ/2 KHZ switch to 20 KHZ.
2) Set SEND FREQ switch to in position.
3) Set MAN switch to in position.
4) Turn MAN TUNE knob fully clockwise.
5) Observe that the FREQUENCY display blanks with the exception of the positive sign.
6) Set 20 KHZ/4 KHZ switch to 4 KHZ.
7) Observe that the FREQUENCY displayed exceeds 4.000 KHZ.
8) Set CONT/STEP switch to STEP.
9) Slowly turn the MAN TUNE control fully counterclockwise.
10) Observe that the FREQUENCY changes in 100 Hz steps with a +4 ±1 Hz offset.
11) Set CONT/STEP switch to CONT.
12) Observe that the FREQUENCY display blanks with the exception of the negative sign.
13) Turn the HZ/SEC knob fully clockwise.
14) Set SINGLE SWEEP UP switch to in position.
15) While varying the UP LIMIT control setting, verify that the FREQUENCY display indication increases when the control is turned clockwise, and decreases when the control knob is turned counterclockwise.
16) Adjust the UP LIMIT control to obtain a FREQUENCY display of 4.000±0.020 KHZ.
17) Set SINGLE SWEEP DOWN switch to in position.
18) While varying the DOWN LIMIT control setting, verify that the FREQUENCY display indication increases when the control is turned clockwise, and decreases when the control is turned counterclockwise.
19) Adjust the DOWN LIMIT control to obtain a FREQUENCY display of 2.000 ± 0.020 KHZ.
20) Set AUTO switch to in position.
21) Observe that the FREQUENCY sweeps between the two limits.
22) While varying the HZ/SEC control, observe that the sweep rate decreases when the control is turned counterclockwise and increases when the control is turned clockwise.

Note: In AUTO SWEEP mode, if the UP LIMIT is set lower than the DOWN LIMIT, the generator will stay at the down limit setting.

23) Set QUIET TERM switch to in position and observe that NOISE/LEVEL/RETURN LOSS display blanks with the exception of negative sign.
24) Set QUIET TERM switch to out position.
25) Set MAN switch to in position.
26) Set SF SKIP switch to in position.
27) While slowly varying the MAN TUNE knob, observe that the Basic Unit generator skips and/or mutes (depending on the option selected) the frequency band from 2450 to 2750 Hz.

E. Filter Response Check

15.05 To perform the filter response check, proceed as follows:

1) Set REC-NOISE switch to in position.
2) Set SEND LEVEL (DBM) thumbwheel switches to +00.0.
3) Vary the MAN TUNE knob to verify that the NOISE/LEVEL/RETURN LOSS display indication follows the C-Message filter response specifications per Bell PUB 41009.
4) Set C-MSG/3 KHZ switch to 3 KHZ.
5) Vary the MAN TUNE control to verify that the NOISE/LEVEL/RETURN LOSS display indication follows the 3 kHz filter response specification.
6) Set NOTCH switch to in position.
7) Vary the MAN TUNE control to verify that the NOISE/LEVEL/RETURN LOSS display follows the notch response specification.
8) Set 60 HZ ≈ switch to in position.
9) Vary the MAN TUNE control to verify that the NOISE/LEVEL/RETURN LOSS display follows the 60 Hz filter response specification.

F. Timer Check

15.06 For timer self-test check, refer to the applicable totalizing measurement plug-in module operating manual. This completes the self-test.

16. BOARD INSTALLATION/ REMOVAL

16.01 This section describes the procedures for installation/removal of individual boards in the Model 3901 Basic Unit. Only the boards and assemblies described below are normally field serviced.

A. Front Panel and Boards

16.02 As shown in Figure 16, the Basic Unit contains the following boards:

- Display
- Range
- Timer
- Generator
- I/O

DANGER: Hazardous voltages exist inside this instrument. Disconnect power cord from unit before proceeding.

16.03 To remove and install individual boards in the Basic Unit, proceed as follows:

1) Remove the mounting screws from the front panel of the Basic Unit and remove the front panel.
2) Remove the Display, Range and Timer boards by inserting the card extractor (stored on rear panel) into the board and pulling forward.

WARNING: To avoid damaging the Generator and I/O boards, they must be removed together.

3) Place the card extractor into the Generator board and pull forward approximately 1/4 inch.
4) Place the card extractor into the I/O board and pull forward approximately 1/4 inch.
5) Grasp both the Generator and the I/O cards, and pull forward until they both clear the Basic Unit.
6) To install the boards, reverse the removal procedure, and gently slide them into the Basic Unit together until they are firmly seated in the edge connector.
7) Replace the basic unit front panel.

16.04 For repair or servicing by HLI, refer to Section 17.

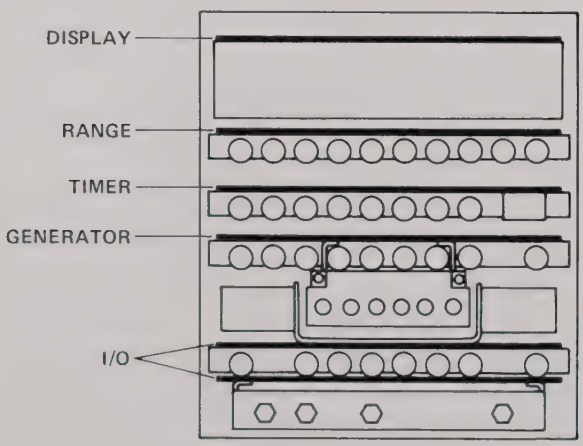

Figure 16. Basic Unit PC Board Identification

B. Rear Panel and Power Supply Board

16.05 The rear panel may be replaced as a complete assembly or, alternately, only the power supply board may be replaced.

WARNING: Disconnect power cord from unit before proceeding.

16.06 To remove and reinstall the rear panel on the Basic Unit, proceed as follows:

1) Remove the six screws on the rear of the enclosure's left and right sides (three screws per side) that hold the rear panel to the enclosure.
2) Remove the two screws on the rear bottom of the enclosure that hold the rear panel to the enclosure.
3) Carefully pull the rear panel out of the enclosure and detach the two cables which connect the rear panel to the Basic Unit. The rear panel may now be repaired or replaced.
4) Replace the rear panel using the reverse procedure.

16.07 To remove and reinstall the power supply board, first remove the rear panel as described in paragraph 16.06 and proceed as follows:

1) Remove the four screws at each corner of the power supply board and disengage it from the PC edge connector.
2) Replace the power supply board using the reverse procedure.

16.08 For repair or servicing by HLI, refer to Section 17.

17. PACKING AND SHIPPING, AND RETURN TO FACTORY

17.01 This section contains procedures to be followed when returning the Model 3901 Basic Unit (or individual boards) to the factory for repair or servicing. Note that most problems with the Basic Unit can be isolated to the individual board level because of functional organization; it is recommended, therefore, that the factory be consulted by telephone or letter before shipping the unit.

A. Complete Unit

17.02 The original packing materials and shipping container for the Basic Unit should be stored for use when shipment (between customer locations or return to factory) becomes necessary.

17.03 If the unit is being returned to HLI for repair or servicing, enclose the following information:

- Type of repair or service required
- Model number and serial number
- Return address

Keep a copy of all information for yourself and refer to your copy in any correspondence with the factory.

17.04 If original packing materials and shipping container are unavailable, repack the unit as follows:

1) If shipping Basic Unit and plug-in modules together, check that the modules are correctly installed.
2) Wrap the unit in heavy paper or plastic. Tape loose edges.
3) Surround the wrapped unit in 5 to 10 cm (2 to 4 inches) thick shock-absorbing material.
4) Place the package in a strong, double-walled shipping container. Fill excess spaces with newspapers.
5) Seal the container securely.
6) Mark the container:
   FRAGILE – DELICATE
   ELECTRONIC INSTRUMENT

B. Basic Unit Boards

17.05 To remove boards from Basic Unit, refer to Section 16.A. To pack and ship a board, refer to Section 17.D.

C. Rear Panel and Power Supply Board

17.06 To remove the rear panel and/or the power supply board, refer to Section 16.B. To pack and ship the rear panel with or without the power supply board, handle it as a unit, following instructions in Section 17.A. To pack and ship the power supply board alone, refer to Section 17.D.

D. Individual Boards

17.07 When a board has been extracted from the Basic Unit, handle the board by the top and bottom edges of the board only. DO NOT handle the rear edge connector. Static electricity may damage the CMOS IC's on the board(s).

17.08 If the board is being returned to HLI for servicing or repair, enclose the following information:

1) Type of service or repair required
2) Model and serial number of the Basic Unit from which the board was extracted
3) Serial number of the board
4) Return address

Retain a copy of all information for yourself and refer to your copy in any correspondence with HLI.

17.09 Boards shipped separately from the factory are enclosed in a special conductive envelope that protects the circuitry from static electricity. This protective envelope should be retained and used for reshipment. If the conductive envelope is not available, DO NOT wrap the board in an ordinary plastic bag or plastic sheeting. Instead, proceed as follows:

1) If available, cover the entire rear edge connector with a conductive shorting bar.

2) Wrap the board in heavy kraft paper.
3) Surround the wrapped board in 5 to 10 cm. (2 to 4 inches) thick shock-absorbing material.
4) Place the package in a strong, double-walled shipping container. Fill excess spaces with newspapers.
5) Seal the container securely.
6) Mark the container: FRAGILE – DELICATE ELECTRONIC INSTRUMENT.

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OPERATING MANUAL
MODEL 3911
IMPULSE NOISE MODULE

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OPERATING MANUAL
MODEL 3911 IMPULSE NOISE MODULE

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TABLES

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FIGURES

1. Model 3911 IMPULSE NOISE Module 1

1. GENERAL

1.01 This manual contains information for operating the Model 3911 IMPULSE NOISE plug-in module in conjunction with the Model 3900 COMMUNICATIONS TEST SYSTEM Basic Unit. This section contains a description and specifications for the Model 3911. Figure 1 shows the front panel.

Figure 1. Model 3911 IMPULSE NOISE Module

A. Functional Description

1.02 The Model 3911 module is designed to meet Bell System standards per Bell System Technical Reference PUB 41009 dated May 1975. The module measures the number of times impulse noise (defined as any excursion of a band-limited signal above a preset threshold) occurs within a specified time period. The Model 3911 is calibrated in dBrn to read peak value of the received signal. Switch selectable Bell standard (7 counts/sec.) and channel-limited (125 counts/sec.) counting rates are provided. Two sets of thumbwheel switches allow setting of low thresholds for both impulse noise (metallic) and impulse noise-to-ground (longitudinal) tests. The Low threshold is adjustable in 1 dB steps from +30 dBrn to +109 dBrn for metallic impulse noise, and from +60 to +139 dBrn for longitudinal impulse noise. The Mid and Hi thresholds are set using the SPREAD (DB) switch which selects the spread from Low to Mid and from Mid to Hi thresholds to be 2, 4, 6, 8 or 10 dB.

B. Specifications

1.03 Specifications for the Model 3911 are contained in Table A.

TABLE A. MODEL 3911 SPECIFICATIONS *

OPERATING MODES	Noise (metallic) Noise-to-ground (longitudinal)
NOISE MEASUREMENT	
Measurement Range	+30 dBrn to +110 dBrn
Low Threshold Settings	+30 dBrn to +109 dBrn
Accuracy	±1 dB
NOISE-TO-GROUND MEASUREMENT	
Measurement Range	+60 dBrn to +140 dBrn
Low Threshold Settings	+60 dBrn to +139 dBrn
Accuracy	±1.5 dB
LO/MID, MID/HIGH THRESHOLD SPREAD	2, 4, 6, 8 or 10 dB
WEIGHTING**	C-message (Psophometric) or 3 kHz flat, switchable holding tone notch and 60 Hz (50 Hz) high-pass filter.
MAXIMUM COUNTING RATE (Switch selected)	7 counts per second (Bell standard) 125 counts per second (channel limited)
COUNTING HIERARCHY	When used with Model 3913 HITS/JITTER Module, impulse noise counts are interlocked with hit and dropout occurences in accordance with Bell System specifications.
DIGITAL DISPLAYS	LO threshold totalizer M (MID) threshold totalizer HI threshold totalizer
COUNT CAPACITY	LO 9999 M (MID) 9999 HI 9999
OVERRANGE INDICATION	When count capacity is exceeded, the display continues counting and flashes
SELF-TEST	Uses Basic Unit Generator
TIMER	5 min., 15 min., or continuous, located in Basic Unit
MODULE INTERLOCKS	"Exclusive Measurement" interlock Measurement is terminated when any Basic Unit noise weighting parameter is changed

TABLE A. MODEL 3911 SPECIFICATIONS (Cont.)

INDICATORS	TONE INTERRUPT NOISE NTG Module ON
MODULE SIZE	Single-width module
MODULE WEIGHT	17 oz. (0.48 kg.)
OPTIONS	.04 Remote Control

*All stated and unstated specifications are intended to comply with Bell System standards as contained in Bell System Technical Reference PUB 41009 dated May 1975

**Specification dependent on Model 3901/3902 Basic Unit

HLI reserves the right to make changes in specifications at any time without notice.

2. OPERATING INSTRUCTIONS

2.01 This section contains the setup procedures for the Model 3911 and related setup procedures for the Basic Unit. Features of the Model 3911 are also described.

A. Setup Procedures

2.02 Set up the Basic Unit as follows:

1) Refer to Section 4 of the Basic Unit Operating Manual (3901-M20) for line interface information.
2) Set POWER switch to in position.
3) Set ABS/REL switch to the desired position. If REL is selected, the low threshold is LOW THR setting plus REL REF setting.
4) If performing balanced-circuit impulse noise measurements, set either the REC-LEVEL or the REC-NOISE switch to in position.
5) If performing impulse noise-to-ground measurements, set REC-NTG switch to in position.
6) Set C-MSG/3 KHZ (PSOPH/3 KHZ) switch to the desired position.
7) If a holding tone is to be used, set NOTCH switch to in position. If a tone is not to be used, set NOTCH switch to out position.
8) Set 60 Hz ≷ (50 Hz ≷) switch to desired position.
9) Set the appropriate timer interval switch (5 MIN, 15 MIN or CONT) to in position.
10) Refer to Section 10 of the Basic Unit Operating Manual (3901-M20) for generator control settings.
11) Set NORM/RETURN LOSS switch to NORM.

2.03 Set up the Model 3911 as follows:

1) Momentarily press the ON/OFF switch and observe that green ON/OFF LED is on.
2) Select counting rate by setting BELL STD/CHNL LTD switch to the appropriate position.
3) Set the appropriate LOW THR thumbwheel switches for the low threshold.
4) Select the DB SPREAD between LO to M and M to HI thresholds by setting the SPREAD (DB) switch to desired spread (2, 4, 6, 8 or 10 dB).

B. Impulse Noise Measurement

2.04 To start the impulse noise measurement, proceed as follows:

1) On the Basic Unit, momentarily press the timer START/STOP switch.
2) When the selected time interval has been completed, the measurement will automatically stop and the number of impulse noise counts will be displayed on the Model 3911 display.
3) If timer interval was set to CONT, stop the timer by pressing the START/STOP switch at the conclusion of the test.
4) Turn off the Model 3911 by momentarily pressing the ON/OFF switch.

Note: Turning on another plug-in module which does not require the use of the timer on the Basic Unit may also turn off the Model 3911.

C. Features

2.05 Tone Interrupt: If the holding tone is lost during an impulse noise measurement, the red TONE INTERRUPT LED will turn on. The LED will remain on until reset by the start of a new measurement period.

2.06 Measurement Interrupt: To discourage the changing of parameters during an impulse noise measurement, the Model 3911 contains an interrupt-sensing circuit that detects certain changes. If any of the switch settings set up per Paragraph 2.02 (with the exception of REC-LEVEL and REC-NOISE switches) are changed during a measurement, the measurement will terminate and the TIMER (MINUTES) display on the Basic Unit will flash at a 1 Hz rate to indicate an interrupted measurement. Turning on the Model 3913 HITS/JITTER Module, or turning off the Model 3911 during a measurement, will also

cause an interrupted measurement condition. When a measurement has been interrupted, repeat the setup procedures.

2.07 Noise Level Measurement: The REC-LEVEL and REC-NOISE switches may be changed without interrupting the measurement. This feature permits verification of both holding tone and noise levels.

2.08 Memory: When the Model 3911 is turned back on after being turned off, the TIMER (MINUTES) display on the Basic Unit and the IMPULSE NOISE display on the Model 3911 will display the same information that was present when the Model 3911 was turned off, if power to the Basic Unit was not interrupted or the timer was not used while the Model 3911 was turned off.

2.09 Counting Heirarchy: When the Model 3911 is being used with the Model 3913 HITS/JITTER Module, any transient qualified as a dropout, a phase hit, or a gain hit will not be counted as impulse noise.

2.10 Overflow: If the number of impulse noise counts exceeds 9999 during a measurement, the overflowed counter(s) will flash to indicate an overflow condition.

2.11 Lamp Test: By activating the lamp test switch when the Model 3911 is on, all segments of the readouts and all the LED indicators can be turned on to verify proper operation of the displays.

2.12 Freeze: The freeze mode may be activated during a measurement without affecting the measurement in process. Counts accumulated during the freeze mode will be displayed as soon as the freeze is removed.

3. SELF-TEST

3.01 This section contains the procedure for self-testing the Model 3911.

3.02 Set up the Basic Unit as follows:

1) Set ABS/REL switch to ABS.
2) Set REC-NOISE switch to in position.
3) Set C-MSG/3 KHz switch to 3 KHz.
4) Set NOTCH switch to out position.
5) Set 5 MIN switch to in position.
6) Set 1004 HZ switch to in position.
7) Set QUIET TERM switch to out position.
8) Set DIAL/TK switch to out position.
9) Set BRIDGE/TERM switch to TERM.
10) Set NORM/RETURN LOSS switch to NORM.
11) Set SEND LEVEL (DBM) thumbwheel switches for +00.5 dBm.
12) Connect looping cord from the NORM-REC jack to the NORM-SEND jack.
13) Set POWER switch to in position.

3.03 Set up the Model 3911 as follows:

1) Momentarily press ON/OFF switch and observe that ON/OFF LED is on.
2) Set BELL STD/CHNL LTD switch to BELL STD.
3) Set NOISE LOW THR thumbwheel switches to 92 dBrn.
4) Set SPREAD (DB) switch to 2.

3.04 Perform self-test procedures as follows:

1) Momentarily press the timer START/STOP switch on the Basic Unit.
2) On the Model 3911, observe that the LO display is counting but that the M and HI displays are not counting.
3) Set the NOISE LOW THR thumbwheel switches to 88 dBrn and observe that the LO, M and HI displays are counting.
4) Set BELL STD/CHNL LTD switch to CHNL LTD and observe that the rate of counting on the three displays increases.
5) Set the NOTCH switch to in position and observe that the TIMER (MINUTES) display is flashing and the LO, M and HI displays have stopped counting.
6) Momentarily press the timer START/STOP switch.
7) Set QUIET TERM switch to in position and observe that the Model 3911 TONE INTERRUPT LED turns on.
8) Set QUIET TERM switch to out position and observe that TONE INTERRUPT LED remains on and the three displays are not counting.
9) Momentarily press the timer START/STOP switch and observe that the timer display is flashing.
10) Momentarily press the timer START/STOP switch and observe that the TONE INTERRUPT LED indicator goes out. This completes the self-test.

4. INSTALLATION/REMOVAL

4.01 This section describes the procedures for installation or removal of the module.

WARNING: Before module installation or removal, make sure that Basic Unit POWER switch is OFF (out position).

4.02 To install the module, proceed as follows:

1) Align the module's PC board with the guides of the Basic Unit slot, and push the module in until the extractor rod contacts the extractor standoff.
2) Turn the extractor screw clockwise while gently pushing the module into the edge connector.
3) Tighten the extractor screw until the module is firmly in place.
4) After the module has been installed, it is recommended that the self-test procedure described in Section 3 be performed to verify that the unit is electrically operational.

4.03 To remove the Model 3911, proceed as follows:

1) Turn the extractor screw counterclockwise until it turns freely.
2) Remove the module by pulling it forward.

WARNING: Handle the module only by top and bottom edges of the PC board.

3) See Paragraph 5.02 for packing and shipping. See Paragraph 5.03 for return to factory.

5. PACKING/SHIPPING, AND RETURN TO FACTORY

5.01 This section contains directions for the packaging and shipment of the module, and special instructions for identification tagging when returning the module to HLI for servicing or repair.

A. Packing and Shipping

WARNING: When the module has been extracted from the Basic Unit, handle the module by the top and bottom edges of the board only. DO NOT handle the rear edge connector. Static electricity may damage the CMOS IC's on the board(s).

5.02 Modules shipped separately from the factory are enclosed in a special conductive envelope that protects the circuitry from static electricity. This protective envelope should be retained and used for reshipment. If the conductive envelope is not available, DO NOT wrap the module in an ordinary plastic bag or plastic sheeting. Instead, proceed as follows:

Note: If the module is being returned for servicing or repair, refer to Paragraph 5.03.

1) If available, cover the entire rear edge connector with conductive shorting bar.
2) Wrap the module in heavy kraft paper.
3) Insert the wrapped module in a strong shipping container. Surround the packaged module with 2 to 4 inches (5 to 10 cm) thick shock-absorbing material. (Common newspapers may be used.)
4) Mark the container: FRAGILE: DELICATE ELECTRONIC INSTRUMENT.

B. Return for Repair or Servicing

5.03 If the module is being returned to HLI for servicing or repair, enclose the following information:

a) Type of service or repair required
b) Model and serial number of the Basic Unit and Expander Unit from which the module was extracted.
c) Model and serial number of the module
d) Your return address

Retain a copy of all information for yourself and refer to your copy in any correspondence with HLI.

PART NO. 3912-M20
Issue 1, March 1978

OPERATING MANUAL
MODEL 3912
DELAY MODULE

Manufactured by
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Hekimian Laboratories, Inc.
9298 Gaither Road
Gaithersburg, Maryland 20877 USA

OPERATING MANUAL
MODEL 3912 DELAY MODULE

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1. GENERAL

1.01 This manual contains information for operating the Model 3912 Delay plug-in module in conjunction with the Model 3900 Communications Test System basic unit. This section contains a description and specifications for the Model 3912. Figure 1 shows the front panel.

Figure 1. Model 3912 Delay Module

A. Functional Description

1.02 The Model 3912 module measures and displays envelope delay distortion. Designed to Bell System standards, it provides forward reference, return reference, and 3rd-point measurements, plus loop and end-to-end capability.

1.03 Using a unit at each end of the circuit, the master and slave modes provide forward and return reference delay measurements. Amplitude repeat capability provides for simultaneous amplitude and delay measurements at the Master Station. A third unit may be used for 3rd-point delay and amplitude measurements.

1.04 Direct loop measurements may be made with a single unit. Dual hold circuits in the basic unit conveniently hold both the measurement and reference line during 2-wire testing. Isolated end-to-end measurements may also be made.

1.05 All measurement modes including the 83-1/3 and 25 Hz modulation frequencies are compatible with WECO and other commercial sets having similar features. Delay is displayed on a 4-digit readout, and level and frequency are continuously monitored by the basic unit. A dc output proportional to delay is provided for use along with the amplitude and frequency outputs of the basic unit for external X-Y plots. The 100 μs per step delay CALIB pushbutton and the operating features of the basic unit generator allow rapid and flexible chart recorder calibration and operation.

1.06 Real time and stored displays of delay and amplitude versus frequency can also be provided on the Model 3980 CRT Display module.

1.07 Measurement frequency and level are controlled by the basic unit generator which features manual tuning, automatic variable rate sweeping, single sweep up, and single sweep down. All sweep limits are front-panel adjustable.

1.08 The "Exclusive Measurement" interlock ensures that no conflicting modules are active during delay measurements.

B. Specifications

1.09 Specifications for the Model 3912 are contained in Table A.

TABLE A. MODEL 3912 DELAY MODULE SPECIFICATIONS

OPERATING MODES	Delay – Master Terminal Delay – Slave Terminal Delay + Amp – Slave Terminal Delay – 3rd-Point Delay – End-to-End
DELAY MEASUREMENT (MASTER AND SLAVE)	
Carrier Frequency Range	300 Hz to 4000 Hz
Carrier Level Range	+10 dBm to –40 dBm
Delay Measurement	±6000 μs (83-1/3 Hz modulation) ±10,000 μs (25 Hz modulation)
Accuracy (83-1/3 Hz modulation)	±10 μs, 600 Hz to 4000 Hz ±30 μs, 300 Hz to 600 Hz usable below 300 Hz
AMPLITUDE REPEAT (SLAVE ONLY)	
Carrier Range	+6 dBm to –20 dBm
Accuracy	±0.5 dB at 0 dBm ±1.0 dB at –10 dBm ±2.0 dB at –20 dBm usable to –30 dBm
END-TO-END SYNC	Adjusts reference frequency over a range of ±0.1%
DISPLAY AVERAGING	Normal – 10 periods of modulation frequency Damped – 100 periods of modulation frequency
ZERO REFERENCE	Push-to-set zero reference for delay measurement
SELF-TEST/CALIBRATION	Pushbutton: increments delay in 100 μs steps, no limit on number of steps
DIGITAL DISPLAY	Delay in μs, with polarity
GENERATOR	
Carrier	Uses basic unit generator
Modulation	25 Hz or 83-1/3 Hz, switch selectable
Modulation Distortion	More than 55 dB below carrier
MODULE INTERLOCKS	"Exclusive Measurement" interlock
INDICATOR	Module ON
MODULE SIZE	Single-width module, 1.35 in. (3.43 cm) W x 6.75 in. (17.2 cm) H x 13.88 in. (35.3 cm) D
MODULE WEIGHT	20 oz (0.57 kg)

2. OPERATING INSTRUCTIONS

2.01 This section contains a description of the set-up procedures for the Model 3912 and related set-up procedures for the basic unit. Features of the Model 3912 are also described.

A. Set-Up Procedures

2.02 Set up the basic unit as follows:

1) Refer to Section 4 of the basic unit operating manual for line interface information.
2) Set ABS/REL switch to ABS.
3) Set REC-LEVEL switch to in position.
4) Set DAMP switch to in position.
5) The 60 HZ ≈ switch should normally be left in the out position. Under conditions of poor signal-to-noise ratio (20 to 30 dB) or high 60 Hz power line noise, set this button in.
6) The frequency/measurement modes for the five types of delay measurements are listed in Table B.
7) Set the SEND LEVEL (DBM) thumbwheel switches to the desired send level.
8) Delay measurements may be made using the fixed 1004 Hz, manual, single-sweep or automatic sweep generator modes. Delay measurements are generally started at a reference frequency of 1004 Hz or 1804 Hz and then completed using the manual or sweep modes.
9) Refer to Section 10 of the basic unit operating manual for send frequency set-up procedures.

2.03 Set up the Model 3912 as follows:

1) Set DAMP switch to out position. If the delay reading fluctuates during a measurement, place the DAMP switch to in position.
2) Set the 83-1/3/25 HZ switch to 83-1/3 HZ (U.S. standard) unless 25 Hz modulation is required.
3) Set all other switches to out position.

B. Loopback Delay Measurement

2.04 To perform a loopback delay measurement, proceed as follows:

1) Connect the line under test to the basic unit at Station A as shown in Figure 2. The line under test must be "looped back" at Station B in accordance with standard practices.
2) Set the basic unit's send level and frequency to the desired reference values (typically 1004 Hz or 1804 Hz).
3) Observe the basic unit to ensure the correct level and frequency are being received, to verify proper looping and connections.
4) Verify that the Model 3912 MASTER/SLAVE, DELAY/DEL + AMP and END-TO-END switches are set to out position.
5) Momentarily press ON/OFF switch on the Model 3912 and observe that ON/OFF indicator is on.
6) Momentarily press ZERO REF switch.
7) Observe that the DELAY readout is 0 ±10 μs at the reference frequency.
8) Delay measurements may now be made relative to the zero delay at the reference frequency.

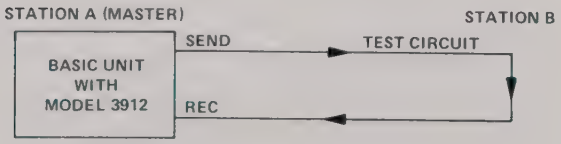

Figure 2. Loopback Delay Measurement Setup

TABLE B. FREQUENCY MEASUREMENT CONDITIONS AND MODES

Note: The upper and lower frequency modes given for each station and mode refer to initial set-up and subsequent measurement, respectively.

MEASUREMENT	STATION A	STATION B	STATION C
LOOPBACK DELAY	REC FREQ	N/A	N/A
FORWARD REFERENCE DELAY	SEND FREQ (to set reference frequency)	REC FREQ (to check incoming signal)	N/A
	REC FREQ (to display measurement frequency)	SEND FREQ (to display measurement frequency)	
RETURN REFERENCE DELAY AND AMPLITUDE	REC FREQ (to check incoming signal)	SEND FREQ (to set reference frequency)	N/A
	SEND FREQ (to display measurement frequency)	REC FREQ (to display measurement frequency)	
3rd-POINT DELAY AND AMPLITUDE	SEND FREQ (to display measurement frequency)	REC FREQ (to display measurement frequency)	SEND FREQ (to set reference frequency)
	REC FREQ (to check incoming signal)	SEND FREQ (to set reference frequency)	EXT FREQ (to display measurement frequency)
END-TO-END DELAY	SEND FREQ (to display measurement frequency)	REC FREQ (to display measurement frequency)	N/A

Note: A simultaneous amplitude response measurement of the line under test may be made by observing the basic unit level display.

C. Forward Reference Delay Measurements

2.05 To perform forward reference delay measurements, proceed as follows:

1) Connect the telephone lines to the basic units at Stations A and B as shown in Figure 3.

Note: Throughout the following procedure, the Master Station will be referred to as Station A, and the Slave Station as Station B.

2) Set Station A and B send level and frequency to the desired reference values (typically 1004 Hz or 1804 Hz).
3) Observe the Station A and B basic units to ensure the correct level and frequency are being received, to verify proper connections.
4) At Station B, set MASTER/SLAVE switch to SLAVE.
5) Momentarily press the ON/OFF switch on each Model 3912 and observe that the ON/OFF indicators are on. The Model 3912 display at Station B should remain blank.
6) Momentarily press ZERO REF switch at Station A. Observe Station A delay readout; it should be stable at 0 ±10 μs, confirming that both modules are operating and that the loop has been established.
7) Station A, sending on the reference line, should maintain the fixed reference frequency and level during the test.
8) Station B, sending on the line under test, selects the frequencies and mode of tuning used for the test. See Table B for additional clarification of the frequency display modes.
9) Station A will now display the delay of the line under test relative to zero delay at the reference frequency.

Note: A simultaneous amplitude response measurement of the line under test may be made by observing the Station A basic unit level display.

D. Return Reference Delay and Amplitude Measurements

2.06 To perform return reference delay and amplitude measurements, proceed as follows:

1) Connect the telephone lines to the basic units at Stations A and B as shown in Figure 4.

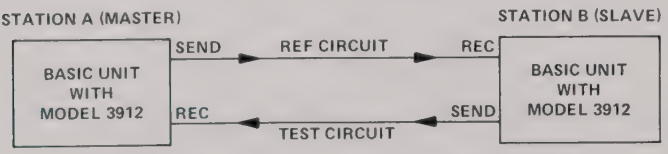

Figure 3. Forward Reference Delay Measurement Setup

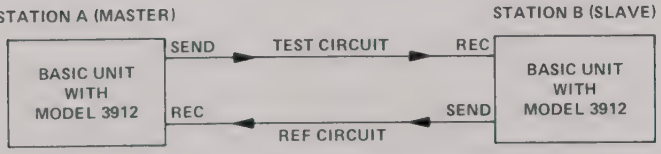

Figure 4. Return Reference Delay and Amplitude Measurement Setup

CAUTION: When using the return reference amplitude measurement mode of operation, the operators must be sure that receive and send levels do not exceed the limits of the line under test, the reference line, or the receive level measurement range/send level range of the basic units.

Note: Throughout the following procedure, the Master Station will be referred to as Station A, and the Slave Station as Station B.

2) Set Station A and B send levels and frequencies to the desired reference values (typically 1004 Hz or 1804 Hz).
3) Observe the levels and frequencies received at Stations A and B to verify proper connections.
4) To make return reference amplitude measurements of the line under test, set the Station B REL REF thumbwheels to match the receive level display and set the Model 3912 DELAY/DEL + AMP switch to DEL + AMP.
5) At Station B, set MASTER/SLAVE switch to SLAVE.
6) Momentarily press the ON/OFF switch on each Model 3912 and observe that the ON/OFF indicators are on. The Model 3912 display at Station B should remain blank.
7) Momentarily press ZERO REF switch at Station A. Observe Station A delay readout; it should be stable at 0 ±10 μs, confirming that both modules are operating, the switch settings are correct, and that the loop has been established.
8) Station B, sending on the reference line, should maintain the fixed reference frequency and send level thumbwheel settings during the test.
9) Station A, sending on the line under test, selects the frequencies and mode of tuning used for the test. See Table B for additional clarification of frequency display modes.
10) Station A will now display the delay of the line under test relative to zero delay at the reference frequency.
11) Station A will also display the amplitude response (if measured) and the test frequency of the line under test on the receive level and send frequency displays.
12) The amplitude response displayed at Station A of the line under test may be given a "0 dB" reference by setting the Station A ABS/REL switch to REL and setting the REL REF thumbwheels to obtain a 0.0 dB level display reading.

E. 3rd-Point Delay and Amplitude Measurements

2.07 To perform 3rd-point delay and amplitude measurements, proceed as follows:

CAUTION: When using the 3rd-point delay and amplitude measurement mode of operation, the operators must be sure that receive and send levels do not exceed the limits of the line under test, the reference line, or the receive level measurement range/send level range of the basic units.

Note: It is assumed that the line under test and reference lines are physically situated so both are accessible at one intermediate location (Station C), where it is necessary to display envelope delay and amplitude.

1) Connect the telephone lines to the basic units at Stations A, B and C as shown in Figure 5.
2) Set all basic unit send levels and frequencies to the desired reference values (typically 1004 Hz or 1804 Hz).
3) Observe all basic units to ensure correct levels and frequencies are being received, to verify proper connection.
4) To make 3rd-point amplitude measurements, set the REL REF thumbwheels at the Station B basic unit to match the receive level display, and set the Model 3912 DELAY/DEL + AMP switch to DEL + AMP.

5) Set MASTER/SLAVE switch to SLAVE at Stations A and B.
6) Momentarily press the ON/OFF switch on each Model 3912 and observe that the ON/OFF indicators are on.
7) Refer to Table B to select the desired frequency measurement mode.
8) Momentarily press ZERO REF switch at Station C. Observe delay readout; it should be stable at 0 ±10 μs confirming that all modules are operating, the switch settings are correct, and that the loop has been established.
9) Stations B and C, sending on the reference line, should maintain the fixed reference frequency and send level thumbwheel settings during the test.
10) Station A, sending on the line under test, selects the frequencies and mode of tuning used for the tests.
11) Station C will now display the delay of the line under test.
12) Station C will also display the amplitude response (if measured) and the test frequency of the line under test on the receive level and frequency displays.
13) The amplitude response displayed at Station C of the line under test may be given a "0 dB" reference by setting the Station C ABS/REL switch to REL and setting the REL REF thumbwheels to obtain a 0.0 dB level display reading.

F. End-to-End Delay Measurement

2.08 To perform the end-to-end delay measurement, proceed as follows:

1) Connect the line under test to the basic units at Stations A and B as shown in Figure 6.
2) Set Station A basic unit send level and frequency to the desired values. Select a send frequency in the center of the channel (1004 Hz or 1804 Hz typical) for the SYNC control adjustment.
3) Observe the LEVEL and FREQUENCY readouts on both basic units to verify proper connections.
4) Set the Station A Model 3912 END-TO-END switch to the in position.

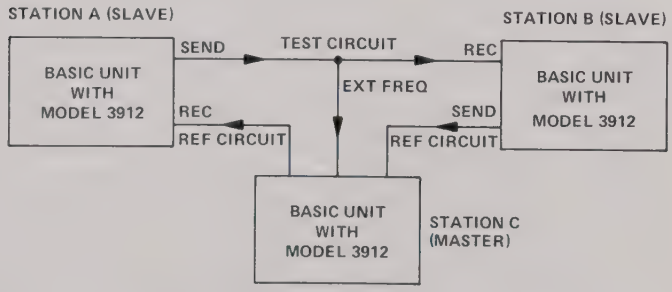

Figure 5. 3rd-Point Delay and Amplitude Measurement Setup

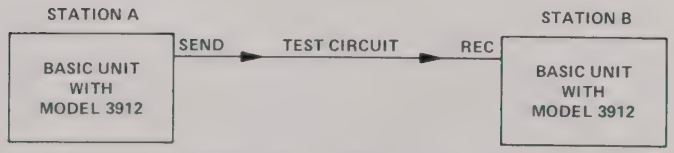

Figure 6. End-to-End Measurement Setup

5) Momentarily press the ON/OFF switch on each Model 3912 and observe that the ON/OFF indicators are on.
6) Momentarily press ZERO REF switch at Station B and observe the direction of the delay drift.
7) Adjust SYNC control to minimize delay drift, i.e., counterclockwise if the delay drift is in a positive direction, and clockwise if the delay drift is in a negative direction.
8) Using a stopwatch or a sweep second hand, note the delay drift in microseconds/second (or minute).

Note: When the delay drift has been minimized, do not readjust the SYNC control during the measurement.

9) Station A, sending on the line under test, selects the frequencies and mode of tuning used for the tests. See Table B for additional clarification of the frequency display modes.
10) Perform the delay measurement as quickly as possible to minimize the errors introduced by the delay drift.
11) An effective method to compensate for delay drift is to set Station A basic unit CONT/STEP to STEP. The delay drift is linear and can be adjusted so that the operator at Station B has sufficient time to take a delay reading (such as 10 seconds/step). For example, at 10 seconds/100 Hz step, the predetermined delay drift in microseconds/second (multiplied by 10) can be subtracted from the delay readings to compensate for the drift.
12) Delay drift values may be verified by selecting a reference frequency at the beginning of the measurement and returning to it periodically to determine the delay drift from the original reading.

Note: A simultaneous amplitude response measurement of the line under test may be made by observing the Station B basic unit level display.

G. Features

2.09 Damping: During normal operation, the Model 3912 averages delay readings over 10 periods (at 83-1/3 Hz, 1 period = 12 ms, and at 25 Hz, 1 period = 40 ms). For noisy conditions, setting the DAMP switch to the in position provides for averaging delay over 100 periods for an update rate of 1.2 seconds at 83-1/3 Hz, and 4.0 seconds at 25 Hz.

2.10 Calibrate: Each time the CALIB switch is momentarily pushed, the delay reading is advanced by 100 μs. This feature, in addition to checking the receive portion of the Model 3912, is useful for checking oscilloscope displays and also allows rapid calibration of an external chart recorder.

2.11 Overrange: When delay readings exceed ±9999 μs, the display will flash at a 1 Hz rate. This will only occur with the 25 Hz modulation rate.

2.12 Lamp Test: By activating the lamp test switch when the Model 3912 is on, all segments of the readouts and all the LED indicators can be turned on to verify proper operation of the displays.

2.13 Freeze: The freeze mode may be activated during a measurement without affecting the measurement in process. Counts accumulated during the freeze mode will be displayed as soon as the freeze is removed.

2.14 "Exclusive Measurement" Interlock: This interlock insures that any module which conflicts with the delay measurement is automatically turned off when the Model 3912 is turned on. If a conflicting module is turned on while the delay module is in operation, the delay module is automatically turned off.

2.15 Delay vs. Frequency Chart Recordings: Chart recordings using an X-Y plotter may be made using the analog dc outputs of frequency, level (DB) and delay. The outputs are available on the basic unit rear panel barrier strip.

3. SELF-TEST

3.01 This section contains the procedure for self-testing the Model 3912.

3.02 Set up the basic unit as follows:

1) Set POWER switch to in position.
2) Set REC-LEVEL switch to in position.
3) Set 1004 HZ switch to in position.
4) Set 20 KHZ/4 KHZ switch to 4 KHZ.
5) Set REL REF (DBM) thumbwheel switches to +00.0.
6) Set SEND LEVEL (DBM) thumbwheel switches to +00.0.
7) Set QUIET TERM switch to out position.
8) Set DIAL/TK switch to out position.
9) Set BRIDGE/TERM switch to TERM.
10) Set NORM/RETURN LOSS switch to NORM.
11) Connect loop cord from basic unit NORM-SEND jack to NORM-REC jack.

3.03 Set up the Model 3912 as follows:

1) Set all switches on Model 3912 to out position.
2) Set 83-1/3 HZ/25 HZ switch to desired position.
3) Momentarily press ON/OFF switch and observe that ON/OFF indicator is on.

3.04 Perform the self-test procedures as follows:

Note: The following procedural steps refer to the Model 3912 unless otherwise indicated.

1) Momentarily press ZERO REF switch and observe that display readout is 0 ±10 μs.
2) Momentarily press CALIB switch and observe that display readout is 100 ±10 μs.
3) Set MAN switch on basic unit to in position.
4) Set CONT/STEP switch on basic unit to CONT.
5) Adjust MAN TUNE knob to obtain 0.600 ±0.010 KHZ FREQUENCY readout on the basic unit.
6) Observe that DELAY readout is 100 ±10 μs.
7) Using MAN TUNE knob, sweep frequency from 600 Hz to 300 Hz and observe that the DELAY readout is 100 ±30 μs.
8) Press and release CALIB switch nine times, to obtain a readout of 1000 μs. (Readout will increase exactly 100 ±1 μs each time CALIB switch is pressed.)
9) Set END-TO-END switch to in position.
10) Observe that the DELAY readout is changing.
11) Set DAMP switch to in position.
12) Observe that the rate of updating slows down.
13) Set DAMP switch to out position.
14) Observe direction of the delay drift.
15) Minimize delay drift by adjusting SYNC control counterclockwise if drift is in a positive direction, clockwise if drift is in a negative direction. This completes the self-test.

4. INSTALLATION/REMOVAL

4.01 This section describes the procedures for installation or removal of the module.

CAUTION: Before module installation or removal, make sure that basic unit POWER switch is OFF (out position).

4.02 To install the module, proceed as follows:

1) Align the module's PC board with the guides of the basic unit slot, and push the module in until the extractor rod contacts the extractor standoff.
2) Turn the extractor screw clockwise while gently pushing the module into the edge connector.
3) Tighten the extractor screw until the module is firmly in place.
4) After the module has been installed, it is recommended that the self-test procedure described in Section 3 be performed to verify that the unit is electrically operational.

4.03 To remove the Model 3912, proceed as follows:

1) Turn the extractor screw counter-clockwise until it turns freely.
2) Remove the module by pulling it forward.

CAUTION: Handle the module only by top and bottom edges of the PC board.

3) See Section 5.02 for packing and shipping. See Section 5.03 for return to factory.

5. PACKING/SHIPPING, AND RETURN TO FACTORY

5.01 This section contains directions for the packaging and shipment of the module, and special instructions for identification tagging when returning the module to HLI for servicing or repair.

A. Packing and Shipping

CAUTION: When the module has been extracted from the basic unit, handle the module by the top and bottom edges of the board only. DO NOT handle the rear edge connector. Static electricity may damage the CMOS IC's on the board(s).

5.02 Modules shipped separately from the factory are enclosed in a special conductive envelope that protects the circuitry from static electricity. This protective envelope should be retained and used for reshipment. If the conductive envelope is not available, DO NOT wrap the module in an ordinary plastic bag or plastic sheeting. Instead, proceed as follows:

Note: If the module is being returned for servicing or repair, refer to Section 5.03.

1) If available, cover the entire rear edge connector with conductive shorting bar.
2) Wrap the module in heavy kraft paper.
3) Insert the wrapped module in a strong shipping container. Surround the packaged module with 2 to 4 inches (5 to 10 cm) thick shock-absorbing material. (Common newspapers may be used.)
4) Mark the container: FRAGILE: DELICATE ELECTRONIC INSTRUMENT.

B. Return for Repair or Servicing

5.03 If the module is being returned to HLI for servicing or repair, enclose the following information:

a) Type of service or repair required
b) Model and serial number of the basic unit or expander unit from which the module was extracted
c) Model and serial number of the module
d) Your return address

Retain a copy of all information for yourself and refer to your copy in any correspondence with HLI.

PART NO. 3913-M20
Issue 3, August 1979

OPERATING MANUAL
MODEL 3913
HITS/JITTER MODULE

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OPERATING MANUAL
MODEL 3913 HITS/JITTER MODULE

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TABLES

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FIGURES

1. Model 3913 HITS/JITTER Module . . 1

1. GENERAL

1.01 This manual contains information for operating the Model 3913 HITS/JITTER Module in conjunction with the Model 3900 COMMUNICATIONS TEST SYSTEM Basic Unit. This section contains a description and specifications for the Model 3913. Figure 1 shows the front panel.

Figure 1. Model 3913 HITS/JITTER Module

A. Functional Description

1.02 The Model 3913 measures and displays phase hits, gain hits, dropouts, phase jitter and amplitude jitter. The module is designed to meet Bell PUB 41009 specifications and comply with CCITT Rec. O.91. Phase and amplitude jitter may be measured with the standard weighting of 20 - 300 Hz or an extended low-frequency weighting of 3 Hz - 300 Hz. The jitter signals are made available on a barrier strip mounted on the rear of the Model 3900 Basic Unit and may also be displayed on the Model 3980 CRT DISPLAY Module for a visual representation of channel impairments. Hit thresholds are front panel selectable and either Bell Standard or channel-limited count rates may be selected. The hit measurements are interlocked with the dropout detector and the Model 3911 IMPULSE NOISE Module in accordance with Bell PUB 41009. The impulse noise lockout is optional on the Model 3920 IMPULSE NOISE Module (CCITT Rec. O.71).

B. Specifications

1.03 Specifications for the Model 3913 are contained in Table A.

TABLE A. MODEL 3913 SPECIFICATIONS

OPERATING MODES	
Hits:	Phase Hits Gain Hits Dropouts
Jitter:	Phase Jitter Amplitude Jitter
RECEIVE HOLDING TONE (All Measurements)	
Frequency Range	990 Hz to 1030 Hz
Level Range	+10 dBm to −40 dBm
PHASE JITTER	
Measurement Range	0.0° to 30.0° peak-to-peak
Accuracy	±5% of reading, ±0.2°
Weighting	Bell Standard (20 Hz - 300 Hz) Bell Standard + LF (3 Hz - 300 Hz)
AMPLITUDE JITTER	
Measurement Range	0.0% to 30.0% peak
Accuracy	±5% of reading, ±0.2%
Weighting	Bell Standard (20 Hz - 300 Hz) Bell Standard + LF (3 Hz - 300 Hz)
PHASE HITS	
Measurement Range	5° to 50°, peak, in 5° steps
Guard Interval	4 ms
Count Capacity	9999 maximum
GAIN HITS	
Measurement Range	±1 to ±10 dB, in 1 dB steps
Guard Interval	4 ms
Count Capacity	9999 maximum
DROPOUTS	
Dropout Range	Greater than or equal to 12 dB
Accuracy	±1.0 dB
Guard Interval	4 ms
Count Capacity	9999 maximum
Response to Noise	Per Bell PUB 41009
HIT/IMPULSE INTERLOCK	When used with Model 3911 IMPULSE NOISE Module, impulse noise counts are interlocked with hit and dropout occurrences in accordance with Bell System specifications. When used with Model 3920 IMPULSE NOISE Module (CCITT Rec. O.71), interlock is optional.
DIGITAL DISPLAYS	Phase/Amplitude Jitter Phase/Gain Hits and Dropouts
OVERRANGE INDICATION	Displays flash when maximum count (hits) or range (jitter) is exceeded.
EXTERNAL JITTER ANALOG OUTPUTS	
Impedance	2 kΩ
Level	100 mV/degree for phase jitter 100 mV/% for amplitude jitter

TABLE A. MODEL 3913 SPECIFICATIONS (Cont.)

EXTERNAL HIT LOGIC OUTPUTS (Front Panel Connector)	
Impedance	10 kΩ
Level	No hit = 0 V dc Hit = +5 V dc
EXTERNAL DEMODULATED CARRIER OUTPUT	
Impedance	10 kΩ
Level	12 V peak-to-peak square wave
CONNECTOR TYPE	Positronic #GH5F, or equal
SELF-TEST	Pushing test button applies a known jitter signal to the module input and Basic Unit generator output.
TIMER	5 min., 15 min., continuous; located in the Basic Unit
GENERATOR	Holding tone supplied by Basic Unit generator
MODULE INTERLOCKS	"Exclusive Measurement" interlock
INDICATORS	CAUTION Module ON
MODULE SIZE	Single-width module,
MODULE WEIGHT	34 oz. (1 Kg.)

HLI reserves the right to make changes in specifications at any time without notice.

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2. OPERATING INSTRUCTIONS

2.01 This section contains the setup procedures for the Model 3913 and related setup procedures for the Basic Unit. Features of the Model 3913 are also described.

A. Setup Procedures for Basic Unit

2.02 To set up the Basic Unit for hits/jitter measurements, proceed as follows:

1) Set the ABS/REL switch to ABS.
2) Select REC LEVEL.
3) Set the REL REF thumbwheel switches to match the LEVEL display reading. This sets the Model 3913 dropout threshold to the correct level.
4) Set the desired timer interval for hit measurements.
5) Set the NORM/RETURN LOSS switch to NORM.
6) Select either ABS or REL as desired for measurement of received signal.
7) Select either REC LEVEL or NOISE as desired.
8) For generator setup, refer to Sections 8 and 9 of Basic Unit Operating Manual, (3901-M20).
9) For line interface, refer to Section 4 of Basic Unit Operating Manual (3901-M20).

B. Setup Procedures for Hit Measurements

2.03 In this mode of operation, the Model 3913 will count and display phase hits, gain hits, and dropouts. Outputs are provided on the Model 3913 front panel connector for hit events.

2.04 In order to measure hits, proceed as follows:

1) Set up the Basic Unit as described in Paragraph 2.02.
2) Turn the Model 3913 on by momentarily pressing the Model 3913 ON/OFF switch.
3) Select the desired counting rate of 7/SEC or CHNL LTD.
4) Set the HIT THRESHOLD thumbwheel switches to the desired phase hit and gain hit threshold.
5) Set the HITS/JITTER switch to HITS.
6) Start the timer by momentarily pressing the START/STOP switch of the Basic Unit timer. When the timer times out, the measurement will stop.
7) In CONT mode only, momentarily press timer START/STOP to stop measurement after desired time interval.
8) The Model 3913 simultaneously measures hits and jitter. To display the current jitter readings, set the HITS/JITTER switch to JITTER and select desired jitter weighting (20 - 300 Hz or 3 - 300 Hz).
9) To turn the Model 3913 off, momentarily press the ON/OFF switch. Turning on a conflicting module or selecting RETURN LOSS mode will also turn the Model 3913 off.

C. Setup Procedures for Jitter Measurements

2.05 In this mode of operation, the Model 3913 will measure and display phase jitter and amplitude jitter with either the Bell Standard weighting of 20 - 300 Hz or the extended low-frequency weighting of 3 - 300 Hz. Demodulated jitter analog signals are available at the Basic Unit rear panel. Refer to Basic Unit Operating Manual (3901-M20), Section 14, for rear panel connections.

2.06 In order to measure phase and amplitude jitter, proceed as follows:

1) Set up the Basic Unit as described in Paragraph 2.02.
2) Turn the Model 3913 on by momentarily pressing the Model 3913 ON/OFF switch.
3) Set the HITS/JITTER switch to JITTER.
4) Select either the 20-300 Hz or 3-300 Hz weighting.
5) The Model 3913 simultaneously measures jitter and hits so that while jitter measurements are being displayed, the Model 3913 continues to collect hits when activated by the timer in the Basic Unit. To display the current hits

information, set the HITS/JITTER switch to HITS.

6) To turn the Model 3913 off, momentarily press the ON/OFF switch. Turning on a conflicting module or selecting RETURN LOSS mode will also turn the Model 3913 off.

D. Features

2.07 Overflow: When the occurrence of hits or dropouts exceeds the count capacity of 9999 during a measurement interval, the overflowed counter(s) will flash at a 1 Hz rate.

2.08 Overrange: When the measured phase or amplitude jitter is beyond the measurement capacity of the Model 3913, the overranged display(s) will flash at a 1 Hz rate.

2.09 CAUTION (LED): The CAUTION indicator will come on whenever the input signal is beyond the range of 990 Hz to 1030 Hz or when a dropout condition exists. The CAUTION indicator will stay on for the duration of a test if a test is initiated by starting the timer before the REL REF thumbwheels have been set for a reading of 0.0 dB (see Paragraph 2.02, Step 3).

2.10 Counting Hierarchy: When a Model 3913 is used with the Model 3911 IMPULSE NOISE Module, any transient qualified as a dropout, phase hit, or a gain hit will not be counted as impulse noise, in accordance with Bell PUB 41009.

2.11 Lamp Test: When the Model 3913 is on the Basic Unit Lamp Test switch (on rear of chassis) will turn on all segments of all displays, including LED indicators, to verify that all of the segments and indicators are functional.

2.12 Freeze: When the Basic Unit FRZ terminal (on rear of chassis) is grounded, all display and indicator information will be preserved until the freeze is removed, even though the input signal may have been removed, or the jitter or hits readings changed during the freeze interval. Upon release of FRZ the counters will immediately indicate the current totals, including hits and dropouts that occurred during the FRZ interval.

2.13 Test: When the Model 3913 TEST switch is pressed, a known jitter signal is generated using the 2-tone sum technique. This signal is internally connected to the Model 3913 input and the Basic Unit generator output. When the switch is pressed, the Basic Unit RMT GEN indicator is on and none of the generator function switches, with the exception of QUIET TERM, has any effect.

2.14 External Logic Outputs: Logic level outputs are provided at the front panel connector for use with external chart recorders or event counters. In 7/sec mode of operation the outputs labeled G (gain hit) and P (phase hit) will go from ground to +5 Vdc for 143 ms when a hit occurs. The output labeled D (dropout) will go from ground to +5 Vdc for 143 ms or the duration of the dropout whichever is longer, when a dropout occurs. In the CHN LTD mode of operation the outputs labeled G (gain hit) and P (phase hit) will go from ground to +5 Vdc for the time it takes the hits circuitry to recover after a hit has occurred and the output labeled D (dropout) will go from ground to +5 Vdc for the duration of the dropout. The output labeled C (demodulated carrier) is a 12 volt peak-to-peak replica of the demodulated carrier that can be connected to an external frequency counter. The center pin labeled GND is the ground return for all front panel outputs.

3. SELF-TEST

3.01 This section contains the procedure for self-testing the Model 3913.

3.02 To perform the Model 3913 self-test, proceed as follows:

1) Turn the Model 3913 on by momentarily pressing the Model 3913 ON/OFF switch. Basic Unit must not be in RETURN LOSS mode.
2) Set the 7/SEC/CHNL LTD switch to 7/SEC.
3) Set the HITS/JITTER switch to JITTER.
4) Set the 20-300 HZ/3-300 HZ switch to 20-300 HZ.
5) Set the phase hit threshold switch to 50^{O}.
6) Set the gain hit threshold to ±10 dB.
7) Press the TEST switch and verify that the Model 3913 reads 16.9^{O} $\pm0.5^{O}$ of phase jitter and 14.6% ±0.5% of amplitude jitter.
8) Set the HITS/JITTER switch to HITS.
9) Set the phase hits threshold to 5^{O}.
10) Set the gain hits threshold to ±1 dB.
11) Start the timer by momentarily pressing the START/STOP switch of the Basic Unit timer.
12) Press the Model 3913 TEST switch and verify that 5^{O} phase hits and 1 dB gain hits are counted.
13) Set the phase hits threshold to 15^{O}.
14) Set the gain hits threshold to 2 dB.
15) Press the Model 3913 TEST switch and verify that no hits are counted. This completes the self-test.

Note: If there is no holding tone input to the Basic Unit, a dropout will be counted each time the TEST switch is released.

4. INSTALLATION/REMOVAL

4.01 This section describes the procedures for installation or removal of the module.

> **WARNING:** Before module installation or removal, make sure that Basic Unit POWER switch is OFF (out position).

4.02 To install the module, proceed as follows:

1) Align the module's PC board with the guides of the Basic Unit slot, and push the module in until the extractor rod contacts the extractor standoff.
2) Turn the extractor screw clockwise while gently pushing the module into the edge connector.
3) Tighten the extractor screw until the module is firmly in place.
4) After the module has been installed, it is recommended that the self-test procedure described in Section 3 be performed to verify that the unit is electrically operational.

4.03 To remove the module, proceed as follows:

1) Turn the extractor screw counterclockwise until it turns freely.
2) Remove the module by pulling it forward.

> **WARNING:** Handle the module only by top and bottom edges of the PC board.

3) See Paragraph 5.02 for packing and shipping. See Paragraph 5.03 for return to factory.

5. PACKING/SHIPPING, AND RETURN TO FACTORY

5.01 This section contains directions for the packaging and shipment of the module, and special instructions for identification tagging when returning the module to HLI for servicing or repair.

A. Packing and Shipping

WARNING: When the module has been extracted from the Basic Unit, handle the module by the top and bottom edges of the board only. DO NOT handle the rear edge connector. Static electricity may damage the CMOS IC's on the board(s).

5.02 Modules shipped separately from the factory are enclosed in a special conductive envelope that protects the circuitry from static electricity. This protective envelope should be retained and used for reshipment. If the conductive envelope is not available, DO NOT wrap the module in an ordinary plastic bag or plastic sheeting. Instead, proceed as follows:

Note: If the module is being returned for servicing or repair, refer to Paragraph 5.03.

1) If available, cover the entire rear edge connector with conductive shorting bar.
2) Wrap the module in heavy kraft paper.
3) Insert the wrapped module in a strong shipping container. Surround the packaged module with 2 to 4 inches (5 to 10 cm) thick shock-absorbing material. (Common newspapers may be used.)
4) Mark the container: FRAGILE: DELICATE ELECTRONIC INSTRUMENT

B. Return for Repair or Servicing

5.03 If the module is being returned to HLI for servicing or repair, enclose the following information:

a) Type of service or repair required
b) Model and serial number of the Basic Unit and Expander Unit from which the module was extracted
c) Model and serial number of the module
d) Your return address

Retain a copy of all information for yourself and refer to your copy in any correspondence with HLI.

PART NO. 3914-M20
Issue 3, August 1979

OPERATING MANUAL
MODEL 3914
NONLINEAR DISTORTION MODULE

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OPERATING MANUAL
MODEL 3914 NONLINEAR DISTORTION MODULE

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FIGURES

1. Model 3914 NONLINEAR DISTORTION Module 1

1. GENERAL

1.01 This manual contains information for operating the Model 3914 NONLINEAR DISTORTION plug-in module in conjuction with the Model 3900 COMMUNICATIONS TEST SYSTEM Basic Unit. This section contains a description and specifications for the Model 3914. Figure 1 shows the front panel.

Figure 1. Model 3914 NONLINEAR DISTORTION Module

A. Functional Description

1.02 The Model 3914 measures and displays 2nd and 3rd order nonlinear distortion. Designed to meet Bell System standards per Bell PUB 41009, it measures channel nonlinear distortion using the 4-tone technique* that supersedes harmonic and total distortion measurement methods.

Using tone pairs centered at 860 Hz and 1380 Hz, the module independently measures and displays the inband 2nd and 3rd order nonlinear intermodulation distortion products. In the NORM mode, distortion products from 10 dB to 69 dB below the test signal are displayed directly for test signal levels between +10 dBm and −40 dBm. In the WIDE RANGE mode, distortion products are displayed from −10 dB to −79 dB for input levels ±4 dB from the REL REF preset level. Test signal level is measured by the Basic Unit and is displayed simultaneously with the distortion reading.

B. Specifications

1.03 Specifications for the Model 3914 are contained in Table A.

*HLI Patent No. 3,862,380

TABLE A. MODEL 3914 SPECIFICATIONS

OPERATING MODES	2nd order nonlinear distortion 3rd order nonlinear distortion
NONLINEAR DISTORTION MEASUREMENT	
Input Signal Level Range	+10 dBm to –40 dBm
Input Signal Frequencies	Nominal: 857, 863, 1372 and 1388 Hz
Distortion Frequencies	2nd order: products centered at 520 and 2240 Hz 3rd order: products centered at 1900 Hz
Distortion Measurement Range	–10 dB to –79 dB (wide range) –10 dB to –69 dB (normal)
Resolution	±1 dB
Accuracy	±1 dB to –70 dB, 2nd order ±1 dB to –75 dB, 3rd order
S/N TEST	Shows effects of channel noise or distortion measurements
DIGITAL DISPLAY	2nd order or 3rd order distortion
OVERRANGE INDICATION	Distortion above –10 dB; display flashes
UNDERRANGE INDICATION	
NORM	Distortion below –69 dB; display blanks, – sign on
WIDE RANGE	Distortion below –79 dB; display blanks, – sign on
SELF-TEST	Distortion test generates precise –35 dB, 2nd and 3rd order distortion in local and transmitted signals
SIGNAL GENERATOR (4 TONE)	
Transmitted Signal Frequencies	857, 863, 1373 and 1388 Hz
Frequency Accuracy	±1 Hz
Level Range	+0.0 dBm to –39.9 dBm (set by Basic Unit)
Level Accuracy	±1 dB
Distortion	Harmonic: 35 dB or more below individual tone level
MODULE INTERLOCKS	"Exclusive Measurement" interlock
INDICATORS	INVALID LEVEL (receive) S/N TEST (receive) SPUR (receive) Module ON
MODULE SIZE	Single-width module
MODULE WEIGHT	22 oz. (.624 kg.)
OPTIONS	.01 Deletes upper tone pair instead of lower tone pair during S/N TEST

HLI reserves the right to make changes in specifications at any time without notice.

2. OPERATING INSTRUCTIONS

2.01 This section contains setup procedures for the Model 3914 and related setup procedures for the Basic Unit. Features of the Model 3914 are also described.

A. Setup Procedures

2.02 Set up the Basic Unit to perform a nonlinear distortion measurement as follows:

1) Set POWER switch to in position.
2) Refer to Section 4 of the Basic Unit Operating Manual (3901-M20) for line interface information.
3) Set ABS/REL to ABS.
4) Set REC-LEVEL switch to in position.
5) Set DAMP switch to in position.
6) Set 60 Hz ≷ switch to in position.
7) Set QUIET TERM switch to out position.
8) Set DIAL/TK switch to out position.
9) Set NORM/RETURN LOSS switch to NORM.

2.03 Set up the Model 3914 as follows:

1) Momentarily press ON/OFF switch and observe that the ON/OFF LED is on.

Note: Turning on a conflicting module (e.g., Model 3912 DELAY), or selecting Return Loss mode or setting the REC-LEVEL switch on the Basic Unit to the out position, will automatically turn the Model 3914 off.

2) Observe that the REMOTE GEN indicator on the Basic Unit is on.

2.04 Perform a nonlinear distortion measurement as follows:

1) Set 2ND/3RD switch to desired position.
2) Set NORM/WIDE RANGE switch to the desired position.
3) In the NORM mode, readings to –69 dB will be displayed without requiring additional adjustments.
4) In the WIDE RANGE mode, set the REL REF (DBM) thumbwheel switches on the Basic Unit to obtain a 0 DB NOISE/LEVEL/RETURN LOSS display reading.
5) Read the distortion on the Model 3914 display. Input level variations of ±4 dB may occur without loss of accuracy once Step 4 has been completed.

B. Features

2.05 DIST TEST: Provides an internal check by generating a test signal with known 2nd and 3rd order distortion levels of –35 dB. The signal is both transmitted and internally looped to the receiver whenever the DIST TEST switch is set to in position.

2.06 S/N TEST: Allows user to remove the lower tone pair from the transmitted signal and increase the higher tone pair by 3 dB to test the distortion measurement for effects of channel noise. (Optionally available with deletion of higher tone pair instead of lower tone pair.) Refer to Table B to determine the correction factor required to compensate for the effect of channel noise on the nonlinear distortion measurement.

2.07 NORM Mode: Distortion products to 69 dB below the test signal are displayed for signal levels between +10 dBm and 40 dBm without requiring any level setup adjustments.

2.08 WIDE RANGE Mode: Distortion products to 79 dB below the test signal are displayed for signal levels between +10 dBm and –40 dBm. The REL REF (DBM) thumbwheel switches on the Basic Unit must be set to obtain a 0 DB LEVEL display readout. In this mode, input level variations of up to ±4 dB will not affect accuracy of the measurement.

2.09 INVALID LEVEL Indicator: The LED comes on when the received signal level is greater than +10 dBm or less than –40 dBm in the NORM mode, or when the signal level varies by more than ±4 dB from the REL REF preset level in the WIDE RANGE mode. When

the LED is on, the distortion display will blank with the exception of the negative sign.

2.10 S/N TEST Indicator: The LED comes on when there is at least a 6 dB difference between received signal tone pairs, indicating a twist, or when a S/N test is in process. The S/N TEST LED will be overridden and turned off any time the INVALID LEVEL LED is on.

2.11 SPUR Indicator: The LED comes on when a spurious signal level is equal to or greater than the received 4-tone test signal level.

2.12 Overrange: The display will flash a −10 at a 1 Hz rate when the distortion exceeds −10 dB.

2.13 Underrange: The display will blank with the exception of the negative sign when the distortion goes below −69 dB in NORM mode, or −79 dB in WIDE RANGE mode.

2.14 Frequency Display Blanking: Turning on the Model 3914 automatically blanks the FREQUENCY display on the Basic Unit to eliminate meaningless numbers caused by the 4-tone test signal.

2.15 Freeze: When the FRZ terminal on the rear panel of the Basic Unit mainframe is grounded, the Model 3914 display will hold its reading and any indicators that are on will remain on until the freeze ground is removed, regardless of any changes that occur in the signal or distortion level while the freeze is in effect.

2.16 Lamp Test: When the Model 3914 is on, the Basic Unit LAMP TEST switch (on rear of chassis) will turn on all segments of all displays, including LED indicators, to verify that all of the segments and indicators are functional.

TABLE B. NONLINEAR DISTORTION MEASUREMENT CORRECTION FACTORS

If the S/N test reading is less than the nonlinear distortion reading by one of the values indicated below. . .	. . . add the corresponding correction factor to the nonlinear distortion reading. (See example)
dB	Correction Factor in dB
7	-0.5
6	-0.6
5	-0.8
4	-1.0
3	-1.3
2	-1.7
1	-2.2
0	-3.0
-1	-4.3
-2	-6.9
-3	*
	* Distortion reading is entirely due to noise.

EXAMPLE: If nonlinear distortion reading is -59 dB and the S/N test reading is -62 dB, then the corrected distortion reading would be: -59 dB plus correction factor of -1.3 dB or -60.3 dB which is rounded off to -60 dB.

3. SELF-TEST

3.01 This section contains the procedure for self-testing the Model 3914.

3.02 Set up the Basic Unit as follows:

1) Set POWER switch to in position.
2) Set ABS/REL switch to ABS.
3) Set REC-LEVEL switch to in position.
4) Set 60 Hz ≂ switch to in position.
5) Set DAMP switch to in position.
6) Set QUIET TERM switch to out position.
7) Set DIAL/TK switch to out position.
8) Set BRIDGE/TERM switch to TERM.
9) Set NORM/RETURN LOSS switch to NORM.

3.03 Set up the Model 3914 as follows:

1) Momentarily press ON/OFF switch and observe that the ON/OFF LED is on.
2) Observe that the REMOTE GEN indicator on the Basic Unit is on.

3.04 Perform the self-test procedure as follows:

Note: The following procedural steps refer to the Model 3914 unless otherwise indicated.

1) Set 2ND/3RD switch to 2ND.
2) Hold DIST TEST switch to in position and observe that display readout is –35 DB.
3) Set 2ND/3RD switch to 3RD.
4) Hold DIST TEST switch to in position and observe that display is –35 DB.
5) Connect looping cord from Basic Unit NORM-SEND jack to NORM-REC jack.
6) Set SEND LEVEL (DBM) thumbwheel switches on the Basic Unit to +00.0.
7) Set NORM/WIDE RANGE switch to WIDE RANGE.
8) Set REL REF (DBM) thumbwheel switches on the Basic Unit to +06.0.
9) Observe that INVALID LEVEL indicator comes on and the display blanks with exception of the negative sign.
10) Set REL REF (DBM) thumbwheel switches to –06.0.
11) Observe that INVALID LEVEL indicator comes on and the display blanks with exception of the negative sign.
12) Set REL REF (DBM) thumbwheel switches to 00.0.
13) Observe that INVALID LEVEL indicator goes off and the display blanks with the exception of the negative sign (this indicates low distortion).
14) Observe that NOISE/LEVEL/RETURN LOSS display readout on the Basic Unit is 0.0±1.0 DB.
15) Set 2ND/3RD switch to 2ND.
16) Observe that display blanks with exception of the negative sign (this indicates low distortion).
17) Set NORM/WIDE RANGE switch to NORM.
18) Observe that NOISE/LEVEL/RETURN LOSS display on the Basic Unit is 0.0±1.0 DBM.
19) Observe that display blanks with exception of the negative sign (this indicates low distortion).
20) Set 2ND/3RD switch to 3RD.
21) Observe that display remains blanked with exception of the negative sign (this indicates low distortion).
22) Momentarily press S/N TEST switch and observe that S/N TEST indicator comes on.
23) Set NORM/WIDE RANGE switch to WIDE RANGE.
24) Hold S/N TEST switch to in position, and set REL REF (DBM) thumbwheel switches on the Basic Unit to +06.0.
25) Observe that INVALID LEVEL indicator comes on and the S/N indicator goes out.
26) Set REL REF (DBM) thumbwheel switches to 00.0 and observe that the S/N indicator comes back on and the INVALID LEVEL indicator goes out. This completes the self-test.

4. INSTALLATION/REMOVAL

4.01 This section describes the procedures for installation or removal of the module.

WARNING: Before module installation or removal, make sure that Basic Unit POWER switch is OFF (out position).

4.02 To install the module, proceed as follows:

1) Align the module's PC board with the guides of the Basic Unit slot, and push the module in until the extractor rod contacts the extractor standoff.
2) Turn the extractor screw clockwise while gently pushing the module into the edge connector.
3) Tighten the extractor screw until the module is firmly in place.
4) After the module has been installed, it is recommended that the self-test procedure described in Section 3 be performed to verify that the unit is electrically operational.

4.03 To remove the module, proceed as follows:

1) Turn the extractor screw counter-clockwise until it turns freely.
2) Remove the module by pulling it forward.

WARNING: Handle the module only by top and bottom edges of the PC board.

3) See Paragraph 5.02 for packing and shipping. See Paragraph 5.03 for return to factory.

5. PACKING/SHIPPING, AND RETURN TO FACTORY

5.01 This section contains directions for the packaging and shipment of the module, and special instructions for identification tagging when returning the module to HLI for servicing or repair.

A. Packing and Shipping

WARNING: When the module has been extracted from the Basic Unit, handle the module by the top and bottom edges of the board only. DO NOT handle the rear edge connector. Static electricity may damage the CMOS IC's on the board(s).

5.02 Modules shipped separately from the factory are enclosed in a special conductive envelope that protects the circuitry from static electricity. This protective envelope should be retained and used for reshipment. If the conductive envelope is not available, DO NOT wrap the module in an ordinary plastic bag or plastic sheeting. Instead, proceed as follows:

Note: If the module is being returned for servicing or repair, refer to Paragraph 5.03.

1) If available, cover the entire rear edge connector with conductive shorting bar.
2) Wrap the module in heavy kraft paper.
3) Insert the wrapped module in a strong shipping container. Surround the packaged module with 2 to 4 inches (5 to 10 cm.) thick shock-absorbing material. (Common newspapers may be used.)
4) Mark the container: FRAGILE: DELICATE ELECTRONIC INSTRUMENT

B. Return for Repair or Servicing

5.03 If the module is being returned to HLI for servicing or repair, enclose the following information:

a) Type of service or repair required
b) Model and serial number of the Basic Unit and Expander Unit from which the module was extracted
c) Model and serial number of the module
d) Your return address

Retain a copy of all information for yourself and refer to your copy in any correspondence with HLI.

PART NO. 3916-M20
Issue 2, November 1980

OPERATING MANUAL
MODEL 3916
RETURN LOSS MODULE

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LIMITED WARRANTY

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OPERATING MANUAL
MODEL 3916 RETURN LOSS MODULE

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1. GENERAL

1.01 This manual contains information for operating the Model 3916 RETURN LOSS plug-in module in conjunction with the Model 3900 COMMUNICATIONS TEST SYSTEM Basic Unit. This section contains a description and specifications for the Model 3916. Figure 1 shows the front panel.

Figure 1. Model 3916 RETURN LOSS Module

A. Functional Description

1.02 The Model 3916 is designed to meet Bell System standards per Bell System Technical Reference PUB 41009 dated May 1975. The module expands the 2-wire and 4-wire sine wave return loss measurements made by the Basic Unit to include echo return loss (ERL), low frequency singing return loss (SRL), high frequency singing return loss (SRL HI) and singing point margin. The POLARITY switch allows 180° phase reversal for singing point measurements. Return loss is displayed directly in dB by the Basic Unit and the difference between the SEND LEVEL and REL REF thumbwheel switch settings on the Basic Unit is the singing point margin in dB.

1.03 The Model 3916 provides the weighted transmit signals for ERL, SRL and SRL HI measurements to the Basic Unit for level control and line interfacing. Sine wave return loss measurement uses the Basic Unit generator.

1.04 Echo suppressors in the circuit under test are disabled by a nominal 1 second burst of 2150 Hz tone that is automatically generated by the Model 3916 whenever the module is turned on, or whenever ECHO SUPPRESS pushbutton is pressed when the module is on.

B. Specifications

1.05 Specifications for the Model 3916 are contained in Table A.

TABLE A. MODEL 3916 SPECIFICATIONS*

MEASUREMENT MODES	SRL HI SRL ERL Sine wave return loss Singing point margin
ALL RETURN LOSS MEASUREMENTS	
Measurement Range	0.0 dB to +50.0 dB (2W) −9.9 dB to +50.0 dB (4W)
Accuracy	±0.5 dB (4W)
Standard Impedance	600 Ω, 900 Ω, ±1% in series with 2.16 μF, ±1% or external standard (2W)
SINGING POINT MEASUREMENT	
Net Gain/Loss	Adjustable from +49.8 dB to −49.8 dB via SEND LEVEL and REL REF thumbwheel switches on the Basic Unit.
Polarity	Changes phase of singing point gain/loss by 180°.
ECHO SUPPRESSOR DISABLE	Provides nominal 1 second burst of 2150 Hz to disable any echo suppressors in test path. Automatically provides burst upon enabling of module. Can be activated at any time when module is ON by pressing ECHO SUPPRESS switch.
GENERATOR	
Transmitted Signal Weighting	Designed to meet Bell PUB 41009 for ERL, SRL, SRL HI
Send Level	Adjustable from 0.0 dBm to −39.9 dBm. Controlled by Basic Unit.
Level Stability	±0.5 dB
Harmonic Distortion	At least 30 dB down
Sine Wave Signal	Uses Basic Unit generator
MODULE INTERLOCKS	"Exclusive Measurement" interlock
INDICATOR	Module ON
MODULE SIZE	Single-width module
MODULE WEIGHT	14 oz. (397 g.)

*All stated and unstated specifications are intended to comply with Bell System standards as contained in Bell System Technical Reference PUB 41009 dated May 1975.

HLI reserves the right to make changes in specifications at any time without notice.

2. OPERATING INSTRUCTIONS

2.01 This section contains setup procedures for the Model 3916 and related setup procedures for the Basic Unit. Features of the Model 3916 are also described.

A. Setup Procedures

2.02 For 2-wire return loss measurement set up the Basic Unit as follows:

1) Set POWER switch in.
2) Set BRIDGE/TERM switch to TERM to use the internal standard impedance, or set the switch to BRIDGE and connect an external standard impedance to the tip and ring of the NORM-REC jack.
3) Set 600Ω/900Ω switch to match the line impedance if the internal standard impedance is being used. If external standard impedance is being used, omit this step.
4) Set NORM/REV switch to NORM.
5) Set 4W/2W switch to 2W.
6) Set NORM/RETURN LOSS switch to RETURN LOSS.
7) Set SEND LEVEL (DBM) thumbwheel switches for the desired output level, not exceeding 0.0 dBm.
8) Set ABS/REL switch to REL.
9) Set REC-LEVEL switch to in position.
10) Set DAMP switch to in position.
11) Refer to Section 2.04 to select desired test signal.
12) Set REL REF (DBM) thumbwheel switches to obtain NOISE/LEVEL/RETURN LOSS display reading of 0.0 DB, with the line under test not connected.
13) Connect the line under test to the NORM-SEND jack and read the return loss directly from the NOISE/LEVEL/RETURN LOSS display. The proper unit of measure is indicated by the DB LED located to the right of the display.

2.03 For 4-wire return loss measurement set up the Basic Unit as follows:

1) Set BRIDGE/TERM switch to TERM.
2) Set 600Ω/900Ω switch to match the line impedance.
3) Set NORM/REV switch to NORM.
4) Set 4W/2W switch to 4W.
5) Set NORM/RETURN LOSS switch to RETURN LOSS.
6) Connect the send and receive lines to the NORM-SEND and NORM-REC jacks, respectively.
7) Set SEND LEVEL (DBM) thumbwheel switches for the desired output level, not exceeding 0.0 dBm.
8) Set ABS/REL switch to REL.
9) Set REC-LEVEL switch to in position.
10) Set DAMP switch to in position.
11) Refer to Section 2.04 to select desired test signal.
12) With the 2-wire side of the hybrid opened, set REL REF (DBM) thumbwheel switches to obtain a NOISE/LEVEL/RETURN LOSS display reading of 0.0 DB.
13) Terminate 2-wire side of the hybrid and read the return loss directly from the NOISE/LEVEL/RETURN LOSS display. The proper unit of measure is indicated by the DB LED to the right of the display.

2.04 Set up the Model 3916 for return loss measurement, as follows:

1) Set SRL HI, SRL, ERL or SINE WAVE switch to in position to select desired test signal.
2) If SINE WAVE switch is set to in position, refer to Section 10 of Basic Unit Operating Manual (M3901-M20) for send frequency setup of the Basic Unit.

2.05 To measure the singing point margin, set the SINGING POINT switch to in position on the Model 3916 and proceed with the Basic Unit as follows:

1) Set ABS/REL switch to REL.
2) Set REC-LEVEL switch to in position.
3) Set 20 KHZ/2 KHZ switch to 20 KHZ.
4) Set SEND FREQ switch to in position.
5) Set BRIDGE/TERM switch to TERM.
6) Set 600Ω/900Ω to match the line impedance.
7) Set NORM/REV switch to NORM.
8) Set 4W/2W switch to 4W.
9) Set NORM/RETURN LOSS switch to RETURN LOSS.

10) Connect the send and receive lines to the NORM-SEND and NORM-REC jacks, respectively.
11) Set REL REF (DBM) and SEND LEVEL (DBM) thumbwheel switches to +9.9 and −39.9 DBM, respectively.
12) Turn up the audio VOLUME.
13) Decrease the REL REF (DBM) thumbwheel switch setting until oscillation just starts. If the REL REF (DBM) thumbwheel switch setting is down to −39.9 DBM and no oscillation is noted, increase the SEND LEVEL (DBM) setting until oscillation just starts. Oscillation occurs as a tone that is readily identified by means of audio, readings on the FREQUENCY counter, and/or NOISE/LEVEL/RETURN LOSS display.
14) The singing point margin (SPM) is obtained by subtracting REL REF (DBM) thumbwheel switch setting from SEND LEVEL (DBM) thumbwheel switch setting. Record the SPM from:

SPM in dB = SEND LEVEL (DBM) − REL REF (DBM)

Example: Oscillation just starts with REL REF (DBM) set at −39.9 and SEND LEVEL (DBM) set at −29.2.

SPM = −29.2 − (−39.9) = +10.7 dB

15) Repeat steps 11 through 14 with the POLARITY switch set to opposite position on the Model 3916. Record the second SPM.
16) Compare the two SPM's calculated above. The lower of the two is the SPM of the test path.

Note: If oscillation cannot be started with the above procedure, the SPM of the channel under test exceeds +49.8 dB.

2.06 When the Model 3916 is on, any echo suppressors in the test path can be disabled by momentarily pressing the ECHO SUPPRESS switch.

B. Features

2.07 Automatic Enable: The Model 3916 is automatically turned on whenever the NORM/RETURN LOSS switch on the Basic Unit is set to RETURN LOSS.

2.08 Echo Suppress: A 1-second echo suppressor disable signal is automatically sent whenever the Return Loss mode is selected or the ECHO SUPPRESS pushbutton is pressed.

2.09 Output Level Limiter: Special circuitry limits the maximum available output level in SINGING POINT mode to approximately the SEND LEVEL (DBM) setting to protect the telephone facility against overload.

3. SELF-TEST

3.01 This section contains the procedures for self-testing the Model 3916.

3.02 Set up the Basic Unit as follows:

1) Set ABS/REL switch to ABS.
2) Set REC-LEVEL switch to in position.
3) Set DAMP switch to in position.
4) Set 20 KHZ/2 KHZ switch to 20 KHZ.
5) Set SEND FREQ switch to in position.
6) Set 1004 HZ switch to in position.
7) Set QUIET TERM switch to out position.
8) Set DIAL/TK switch to out position.
9) Set BRIDGE/TERM switch to TERM.
10) Set 4W/2W switch to 4W.
11) Set NORM/RETURN LOSS switch to RETURN LOSS.
12) Set REL REF (DBM) thumbwheel switches to +09.0.
13) Set SEND LEVEL (DBM) thumbwheel switches to +00.0.
14) Connect looping cord from NORM-REC jack to NORM-SEND jack.
15) Set POWER switch to in position.
16) Turn VOLUME knob for comfortable listening level.

3.03 Perform self-test procedure as follows:

1) Set SRL HI switch to in position on the Model 3916.
2) Observe that the NOISE/LEVEL/RETURN LOSS display reads −0.9 ±0.5 DBM, FREQUENCY display 2.900 ±0.100 KHZ, and REMOTE GEN LED is on. Also, note the high frequency noise-like audio signal.
3) Set SRL switch to in position on the Model 3916.
4) Observe that the NOISE/LEVEL/RETURN LOSS display reads −0.9 ±0.5 DBM, FREQUENCY display 0.400 ±0.100 KHZ, and REMOTE GEN LED is still on. Also, note the low frequency noise-like audio signal.
5) Set ERL switch to in position on the Model 3916.
6) Observe that the NOISE/LEVEL/RETURN LOSS display reads −0.9 ±0.5 DBM, FREQUENCY display 1.350 ±0.150 KHZ, and REMOTE GEN LED is still on. Also, note the mid-range frequency noise-like audio signal.
7) Set SINGING POINT switch to in position on the Model 3916.
8) Decrease REL REF (DBM) thumbwheel switch setting until oscillation occurs. The switch setting should be 0 ±1 dBm when the oscillation occurs.
9) Set SINE WAVE switch to in position on the Model 3916.
10) Observe that the NOISE/LEVEL/RETURN LOSS display reads 0.0 ±0.2 DBM, FREQUENCY display 1.004 ±0.001 KHZ, and that the REMOTE GEN LED is off.
11) Momentarily press ECHO SUPPRESS switch on the Model 3916.
12) Observe that the NOISE/LEVEL/RETURN LOSS display reads 0.0 ±1.0 DBM, FREQUENCY display 2.150 ±0.150 KHZ, and that the REMOTE GEN LED comes back on. After approximately 1 second, the NOISE/LEVEL/RETURN LOSS display should read 0.0 ±0.2 DBM, FREQUENCY display 1.004 ±0.001 KHZ, and the REMOTE GEN LED should go off. This completes the self-test.

4. INSTALLATION/REMOVAL

4.01 This section describes the procedures for installation or removal of the module.

CAUTION: Before module installation or removal, make sure that the Basic Unit POWER switch is OFF (out position).

4.02 To install the module, proceed as follows:

1) Align the module's PC board with the guides of the Basic Unit slot, and push the module in until the extractor rod contacts the extractor standoff.
2) Turn the extractor screw clockwise while gently pushing the module into the edge connector.
3) Tighten the extractor screw until the module is firmly in place.
4) After the module has been installed, it is recommended that the self-test procedure described in Section 3 be performed to verify that the unit is electrically operational.

4.03 To remove the module, proceed as follows:

1) Turn the extractor screw counterclockwise until it turns freely.
2) Remove the module by pulling it forward.

CAUTION: Handle the module only by top and bottom edges of the PC board.

3) See Section 5.02 for packing and shipping. See Section 5.03 for return to factory.

5. PACKING/SHIPPING, AND RETURN TO FACTORY

5.01 This section contains directions for the packaging and shipment of the module, and special instructions for identification tagging when returning the module to HLI for servicing or repair.

A. Packing and Shipping

CAUTION: When the module has been extracted from the Basic Unit, handle the module by the top and bottom edges of the board only. DO NOT handle the rear edge connector. Static electricity may damage the CMOS IC's on the board(s).

5.02 Modules shipped separately from the factory are enclosed in a special conductive envelope that protects the circuitry from static electricity. This protective envelope should be retained and used for reshipment. If the conductive envelope is not available, DO NOT wrap the module in an ordinary plastic bag or plastic sheeting. Instead, proceed as follows:

Note: If the module is being returned for servicing or repair, refer to Section 5.03.

1) If available, cover the entire rear edge connector with conductive shorting bar.
2) Wrap the module in heavy kraft paper.
3) Insert the wrapped module in a strong shipping container. Surround the packaged module with 2 to 4 inches (5 to 10 cm) thick shock-absorbing material. (Common newspapers may be used.)
4) Mark the container: FRAGILE: DELICATE ELECTRONIC INSTRUMENT

B. Return for Repair or Servicing

5.03 If the module is being returned to HLI for servicing or repair, enclose the following information:

a) Type of service or repair required
b) Model and serial number of the Basic Unit or Expander Unit from which the module was extracted.
c) Model and serial number of the module
d) Your return address

Retain a copy of all information for yourself and refer to your copy in any correspondence with HLI.

PART NO. 3918-M20
Issue 2, November 1980

OPERATING MANUAL
MODEL 3918
P/AR MODULE

Manufactured by
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Telex 89-8399

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OPERATING MANUAL
MODEL 3918 P/AR MODULE

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1. GENERAL

1.01 This manual contains information for operating the Model 3918 P/AR plug-in module in conjunction with the Model 3900 COMMUNICATIONS TEST SYSTEM Basic Unit. This section contains a description and specifications for the Model 3918 P/AR. Figure 1 shows the front panel.

Figure 1. Model 3918 P/AR Module

A. Functional Description

1.02 The Model 3918 measures and displays the P/AR rating of a voice channel. Designed to Bell System specifications, the P/AR (peak-to-average ratio) rating measures the simultaneous effects of envelope delay distortion, frequency response problems, and poor return loss on voiceband data signals.

1.03 P/AR readings from 0 to 120 are displayed on the module's own digital display. A DAMP pushbutton is provided to reduce display fluctuations when required. The received test signal level is simultaneously displayed by the Basic Unit. A CAUTION indicator shows the presence of interfering signals or low test signal level that could cause errors in the reading.

1.04 The module generates the complex P/AR signal spectrum and sends it to the Basic Unit for line interfacing and send level control. A unique TEST pushbutton generates a test signal with a known P/AR rating for verifying module operation.

1.05 The module is compatible with all other P/AR measuring equipment meeting current Bell System specifications.

B. Specifications

1.06 Specifications for the Model 3918 are contained in Table A.

TABLE A. MODEL 3918 P/AR MODULE SPECIFICATIONS*

OPERATING MODES	P/AR
P/AR MEASUREMENT	
Accuracy	±2 P/AR units (30 – 110) ±4 P/AR units (0 – 120)
Resolution	1 P/AR unit
Range	0 to 160 P/AR units
Input Level Range	0 to –40 dBm
Detection	Full-wave rectified average detector and absolute peak detector
DIGITAL DISPLAY	3 digits, direct reading in P/AR units
DISPLAY RESPONSE TIME	5 seconds from no signal 3 seconds for 10 P/AR unit step Damped (average of 10 readings)
OVERRANGE INDICATION	Flashing display
UNDERRANGE INDICATION	Blank display with (–) sign (includes sine wave signal inputs)
SELF-TEST	
Type of Circuit	All-pass network
Test Configuration	Pushing test button applies P/AR disturbed signal to module input and generator output
GENERATOR	
Line Spectrum	Designed to meet the requirements of Bell PUB 41009 for frequency, magnitude, phase, and distortion
Line Signal Stability	64 ms period, ±0.1%
Send Level	Variable from 0 dBm to –39.9 dBm True RMS via SEND LEVEL thumbwheel switches on Basic Unit
MODULE INTERLOCKS	"Exclusive Measurement" interlock
INDICATORS	CAUTION Module ON
MODULE SIZE	Single-width module
MODULE WEIGHT	18 oz. (510 g.)

*All stated and unstated specifications are intended to comply with Bell System standards as contained in Bell System Technical Reference PUB 41009 dated May 1975

HLI reserves the right to make changes in specifications at anytime without notice.

2. OPERATING INSTRUCTIONS

2.01 This section contains the setup procedures for the Model 3918 and related setup procedures for the Basic Unit. Features of the model 3918 are also described.

A. Setup Procedures

2.02 To set up the Model 3918, proceed as follows:

1) Turn on the Model 3918 by momentarily pressing the ON/OFF switch.

Note: The Model 3918 will only turn on if the Basic Unit is not in the RETURN LOSS mode and only if the REC LEVEL is selected. For line interface, refer to Section 4 of the Basic Unit Operating Manual (3901-M20).

2) At the Basic Unit, the maximum setting for SEND LEVEL (DBM) thumbwheels should not exceed +00.0 dBm. Select REC LEVEL and DAMP. The 60 Hz filter may be used to eliminate the effects of line interference. RETURN LOSS should **not** be selected since the Model 3918 will not turn on in the RETURN LOSS mode. (When the Model 3918 is on, the REMOTE GEN indicator will be on, indicating that none of the generator function switches, with the exception of QUIET TERM, has any effect.)

3) At the Model 3918, set DAMP switch to the in position to minimize the effects of noise. In order to check the operation of the P/AR module, press the TEST pushbutton. This provides a P/AR disturbed signal that is internally looped and also supplied to the SEND jack on the Basic Unit.

2.03 To turn the Model 3918 off, momentarily press the ON/OFF switch. Turning on a conflicting module (e.g., Model 3912 DELAY) or selecting RETURN LOSS or going out of REC LEVEL measurement mode will also turn the Model 3918 off.

B. Features

2.04 DAMP: The normal display update rate of the Model 3918 is 3.125 per second. With the DAMP switch in the in position, 10 readings will be averaged, giving a display update rate of 0.3125 per second (3.2 seconds per update).

2.05 TEST: In this mode the output of the P/AR generator is applied to the P/AR receiver input and is also connected to the Basic Unit SEND jack. The resulting P/AR reading should be 50 ±2 P/AR units.

2.06 Overflow: When the P/AR indication exceeds 160; the display flashes **160** at a 1 Hz rate.

2.07 Underrange: When the P/AR reading of the signal is less than 0 P/AR units, the display will blank and a minus sign will come on. A sine wave input to the Basic Unit REC jack while the Model 3918 is on will also show this underrange condition.

2.08 Frequency Display Blanking: The Basic Unit FREQUENCY display is normally blanked when the Model 3918 is on. This feature can be disabled at the customer's option.

2.09 CAUTION: The CAUTION indicator system detects loss of input signal or the presence of an interfering spurious signal.

2.10 Lamp Test: The mainframe LAMP TEST switch (on rear of chassis) will turn on all segments of all displays, including LED indicators, to verify that all of the segments and indicators are functional when the Model 3918 is on.

2.11 Freeze: When the mainframe FRZ terminal (rear of chassis) is grounded, the display will hold the P/AR reading until the freeze is removed, even though the input signal may have been removed, or the P/AR reading changed during the freeze interval.

3. SELF-TEST

3.01 To perform self-test of the Model 3918, proceed as follows:

1) Follow the setup procedure of Section 2.
2) Connect a looping cord from the Basic Unit SEND jack to REC jack. Set the thumbwheel switches to +00.0 dBm. Observe a P/AR reading of 100 ±2 P/AR units. Push the Model 3918 TEST button and observe a reading of 50 ±2 units. This completes the self-test.

4. INSTALLATION/REMOVAL

4.01 This section describes the procedures for installation or removal of the module.

CAUTION: Before module installation or removal, make sure that Basic Unit POWER switch is OFF (out position).

4.02 To install the module, proceed as follows:

1) Align the module's PC board with the guides of the Basic Unit slot, and push the module in until the extractor rod contacts the extractor standoff.
2) Turn the extractor screw clockwise while gently pushing the module into the edge connector.
3) Tighten the extractor screw until the module is firmly in place.
4) After the module has been installed, it is recommended that the self-test procedure described in Section 3 be performed to verify that the unit is electrically operational.

4.03 To remove the module, proceed as follows:

1) Turn the extractor screw counter-clockwise until it turns freely.
2) Remove the module by pulling it forward.

CAUTION: Handle the module only by top and bottom edges of the PC board.

3) See Section 5.02 for packing and shipping. See Section 5.03 for return to factory.

5. PACKING/SHIPPING, AND RETURN TO FACTORY

5.01 This section contains directions for the packaging and shipment of the module, and special instructions for identification tagging when returning the module to HLI for servicing or repair.

A. Packing and Shipping

CAUTION: When the module has been extracted from the Basic Unit, handle the module by the top and bottom edges of the board only. DO NOT handle the rear edge connector. Static electricity may damage the CMOS IC's on the board(s).

5.02 Modules shipped separately from the factory are enclosed in a special conductive envelope that protects the circuitry from static electricity. This protective envelope should be retained and used for reshipment. If the conductive envelope is not available, DO NOT wrap the module in an ordinary plastic bag or plastic sheeting. Instead, proceed as follows:

Note: If the module is being returned for servicing or repair, refer to Section 5.03.

1) If available, cover the entire rear edge connector with conductive shorting bar.
2) Wrap the module in heavy kraft paper.
3) Insert the wrapped module in a strong shipping container. Surround the packaged module with 2 to 4 inches (5 to 10 cm) thick shock-absorbing material. (Common newspapers may be used.)
4) Mark the container: FRAGILE: DELICATE ELECTRONIC INSTRUMENT.

B. Return for Repair or Servicing

5.03 If the module is being returned to HLI for servicing or repair, enclose the following information:

a) Type of service or repair required
b) Model and serial number of the Basic Unit or Expander Unit from which the module was extracted
c) Model and serial number of the module
d) Your return address

Retain a copy of all information on the tag for yourself and refer to your copy in any correspondence with HLI.

PART NO. 3923-M20
Issue 2, May 1978

OPERATING MANUAL
MODEL 3923
VOM/CAP MODULE

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OPERATING MANUAL
MODEL 3923 VOM/CAP MODULE

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1. GENERAL

1.01 This manual contains information for operating the Model 3923 VOM/CAP plug-in module in conjunction with the Model 3900 Communications Test System basic unit. This section contains a description and specifications for the Model 3923. Figure 1 shows the front panel.

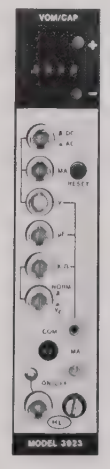

Figure 1. Model 3923 VOM/CAP Module

A. Functional Description

1.02 The Model 3923 measures AC and DC voltage and current; resistance; resistance in the presence of a DC voltage, and capacitance. The Model 3923 input is isolated electrically from the basic unit. Front panel pushbuttons are interlocked to prevent parameter intermixing. The ranges of measurement are shown in the specifications.

B. Specifications

1.03 Specifications for the Model 3923 are contained in Table A.

TABLE A. MODEL 3923 SPECIFICATIONS

DC VOLTAGE	
Range	0 to ±199.9 V dc
Accuracy	±1% reading ±2 least significant digit
Input Resistance	1 MΩ
AC VOLTAGE	
Range	0 to 199.9 V ac
Accuracy	± 1% reading ± 2 least significant digit, 20 Hz-20 kHz ± 3% reading ± 2 least significant digit, 20 kHz-50 kHz
Input Impedance	1 MΩ shunted by approx. 75 pF
Meter Circuit	Average-responding, sine wave rms calibrated
DC CURRENT	
Range	0 to ±199.9 mA
Accuracy	±1% reading ±2 least significant digit
Voltage Drop	320 mV maximum
AC CURRENT	
Range	0 to 199.9 mA
Accuracy	± 1% reading ± 2 least significant digit, 20 Hz-20 kHz ± 3% reading ± 2 least significant digit, 20 kHz-50 kHz
Voltage Drop	320 mV maximum
Meter Circuit	Average-responding, sine wave rms calibrated
CAPACITANCE	
Range	0 to 19.99 μF (2 ranges)
Accuracy	± 1% reading± 2 least significant digit
Range Selection	Autoranging
RESISTANCE	
Range	0 to 1999 kΩ (4 ranges)
Accuracy	± 1% reading± 2 least significant digit
Range Selection	Autoranging
Foreign Voltage	V_f up to± 2 V dc
DIGITAL DISPLAY	3-1/2 digits
OVERLOAD PROTECTION	
Voltage	600 V dc or peak ac at 60 Hz for 1 minute
Resistance, Capacitance	300 V dc or peak ac at 60 Hz, decreasing 6 dB/octave above 60 Hz

TABLE A. MODEL 3923 SPECIFICATIONS (Cont.)

Current	Combined Thermal/Magnetic circuit breaker with Manual Reset, 1 A capacity. Capable of interrupting with Station Battery voltage applied
High Voltage Impulse	Capable of withstanding simulated lightning strike per Bell PUB 41009
Longitudinal Voltage	200 V RMS (dc or ac at 60 Hz), dropping 6 dB/octave above 60 Hz per Bell PUB 41009
MODULE INDICATOR	Module ON
MODULE SIZE	Single-width module; 1.35 in. (3.43 cm) W x 6.75 in. (17.2 cm) H x 13.88 in. (35.3 cm) D
MODULE WEIGHT	35 oz (1 kg)

2. OPERATING INSTRUCTIONS

2.01 This section contains the set-up procedure for the Model 3923 and related set-up procedures for the basic unit. Features of the Model 3923 are also described.

A. Set-Up Procedures

2.02 The Model 3923 is set up for the various modes of measurement as follows:

1) Set basic unit power switch to in position.
2) Set Model 3923 ON/OFF switch to in position. Observe that green LED comes on.
3) Connect "common" test lead to the black COM input terminal.
4) Connect "hot" test lead to either red input terminal on the Model 3923 front panel. The upper red unmarked input terminal is for voltage, capacitance, and resistance. The lower red input terminal is for current (MA).

CAUTION: Always set module controls before attempting measurement.

2.03 Voltage Measurement.

1) Set DC/AC switch to desired mode.
2) Set V switch to in position.
3) Connect test leads to system under test.
4) Read voltage in volts on Model 3923 display.
5) For DC-V measurements, the polarity indicated is relative to the COM terminal.
6) For AC-V measurements, the reading is average-responding and calibrated in rms for a sinusoidal input.

2.04 Current Measurement.

1) Perform AC-V and DC-V measurements (para. 2.03) to be certain that system under test is de-energized.
2) Set DC/AC switch to desired mode.
3) Set MA switch to in position.
4) Change test lead from V to MA jack.
5) Connect test leads to system under test.
6) Energize system.

Note: If the circuit breaker trips, take corrective action to remove the cause. The circuit breaker will not reset if overload continues. To reset, press RESET switch and continue with measurement.

7) Read current in milliamperes on Model 3923 display.
8) De-energize system before disconnecting test leads.
9) For DC-MA measurements, the polarity indicated is relative to the COM terminal.
10) For AC-MA measurements, the reading is average-responding and calibrated in rms for a sinusoidal input.

2.05 Capacitance Measurement.

2.06 In capacitance measurements, the presence of foreign ac voltage affects the accuracy of the measurement. Figure 2 shows the relationship between the measurement error and the magnitude of 60 Hz foreign voltage. For example, when measuring from 2 to 20 μF capacitance in the presence of 0.1 V rms of 60 Hz, the meter reading can be in error by as much as ± 0.15 μF. The effect of the foreign voltage on the capacitance measurement can be minimized by taking two readings, once with test leads connected normally, and once with leads reversed, and taking the average of the two readings.

1) Perform DC-MA measurement to discharge the circuit of any residual charge which may be present.
2) Perform DC-V and AC-V measurements. If any DC voltage is present, capacitance measurement should not be attempted. If any AC voltage is present, accuracy will suffer as noted above.
3) Perform KΩ-NORM measurement to measure the circuit leakage resistance which should be greater than 1000 kΩ for accurate capacitance measurement.
4) Set μF switch to in position.
5) Read capacitance in μF on Model 3923 display.
6) Reverse test leads and take another reading.

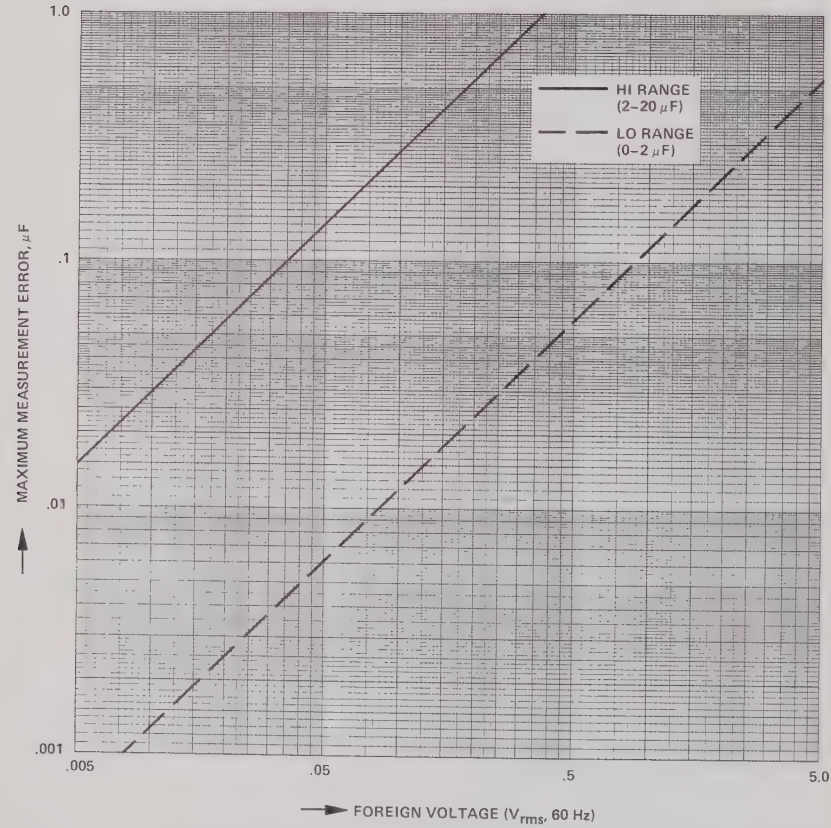

Figure 2. Effect of Foreign Voltage on Capacitance Measurement

7) Average the readings from Steps 5 and 6 to obtain the actual capacitance value.

2.07 Resistance Measurement.

2.08 Presence of ac or dc voltages can affect the accuracy of this measurement. For greater accuracy, take two readings, once with test leads normal, once with test leads reversed, and average the two readings.

1) Perform AC-V and DC-V measurements (Section 2.03) to be certain that system under test is de-energized.
2) If voltage measurement indicates AC-V less than 2.5 volts and DC-V 0.0, proceed:
   a) Set NORM/V_f switch to NORM.
   b) Set KΩ switch to in position.
   c) Read resistance in kilohms on Model 3923 display.
   d) Reverse test leads and again read resistance in kilohms.
   e) If readings of (c) and (d) above are different, then a small amount of DC-V is present. The average read-

ing will be the correct resistance.

3) If voltage measurement indicates 0.0 AC-V, and DC-V is present, proceed:
   a) If DC voltage exceeds ± 2 volts, remove the voltage source from the circuit and check for voltage again.
   b) If DC voltage is within ± 2 volts, set NORM/V_f switch to V_f.

Note: V_f mode should be used only when necessary (i.e., when foreign DC voltage cannot be removed).

   c) Set KΩ switch to in position.
   d) Read resistance in kilohms on Model 3923 display, taking two successive identical readings (within 2 LSD) to be certain instrument has settled.

B. Features

2.09 Units of measurement: The Model 3923 always displays the same units for a selected mode of operation; units are milliamperes, volts, microfarads, and kilohms.

2.10 Overload indication (MA mode only): Tripping the RESET circuit breaker will disable the Model 3923 and indicate a display of dashes. Pushing the RESET in again will return the Model 3923 to normal operation. The Model 3923 will not RESET if an overload is still present.

2.11 Overload protection: The Model 3923 is designed to disconnect the resistance and capacitance functions if excessive AC or DC voltage is present.

2.12 Overrange: The Model 3923 will display a reading of 1999 flashing at a 1 Hz rate if the measurement exceeds the range of the Model 3923.

2.13 Input Connectors: The Model 3923 input connectors are an industry standard miniature banana jack, spaced at the standard 0.5 inch dual spacing. Connectors and test leads are readily available as shielded, unshielded and individual test leads.

2.14 Foreign voltage mode: Permits measurement of resistance with up to ± 2 V dc of foreign voltage present on circuit.

3. SELF-TEST

3.01 This section contains the procedures for self-testing the Model 3923.

1) With no test leads connected display should read:

	Reading Upper Limit	Reading Lower Limit
DC Volts	+00.0	–00.0
DC Current	+00.0	–00.0
AC Volts	00.2	00.0
AC Current	00.2	00.0
Capacitance	.002	.000
Resistance (either mode)	n/a	1.999 and flashing

2) With test leads connected together display should read:

DC Volts	+00.0	–00.0
DC Current	+00.0	–00.0
AC Volts	00.2	00.0
AC Current	00.2	00.0
Capacitance	.005	.000
Resistance (either mode)	.001	.000

3.02 Further self-testing requires a standard for the mode to be tested. The required accuracy of the standard is ±0.1%. This completes the self-test.

4. INSTALLATION/REMOVAL

4.01 This section describes the procedures for installation or removal of the module.

CAUTION: Before module installation or removal, make sure that basic unit POWER switch is OFF (out position).

4.02 To install the module, proceed as follows:

1) Align the module's PC board with the guides of the basic unit slot, and push the module in until the extractor rod contacts the extractor standoff.
2) Turn the extractor screw clockwise while gently pushing the module into the edge connector.
3) Tighten the extractor screw until the module is firmly in place.
4) After the module has been installed, it is recommended that the self-test procedure described in Section 3 be performed to verify that the unit is electrically operational.

4.03 To remove the Model 3923, proceed as follows:

1) Turn the extractor screw counter-clockwise until it turns freely.
2) Remove the module by pulling it forward.

CAUTION: Handle the module only by top and bottom edges of the PC board.

3) See Section 5.02 for packing and shipping. See Section 5.03 for return to factory.

5. PACKING/SHIPPING, AND RETURN TO FACTORY

5.01 This section contains directions for the packaging and shipment of the module, and special instructions for identification tagging when returning the module to HLI for servicing or repair.

A. Packing and Shipping

CAUTION: When the module has been extracted from the basic unit, handle the module by the top and bottom edges of the board only. DO NOT handle the rear edge connector. Static electricity may damage the CMOS IC's on the board.

5.02 Modules shipped separately from the factory are enclosed in a special conductive envelope that protects the circuitry from static electricity. This protective envelope should be retained and used for reshipment. If the conductive envelope is not available, DO NOT wrap the module in an ordinary plastic bag or plastic sheeting. Instead, proceed as follows:

Note: If the module is being returned for servicing or repair, refer to Section 5.03.

1) If available, cover the entire rear edge connector with conductive shorting bar.
2) Wrap the module in heavy kraft paper.
3) Insert the wrapped module in a strong shipping container. Surround the packaged module with 2 to 4 inches (5 to 10 cm) thick shock-absorbing material. (Common newspapers may be used.)
4) Mark the container: FRAGILE: DELICATE ELECTRONIC INSTRUMENT

B. Return for Repair or Servicing

5.03 If the module is being returned to HLI for servicing or repair, enclose the following information:

a) Type of service or repair required
b) Model and serial number of the basic unit or expander unit from which the module was extracted
c) Model and serial number of the module
d) Your return address

Retain a copy of all information for yourself and refer to your copy in any correspondence with HLI.

HLI HEKIMIAN LABORATORIES INC.